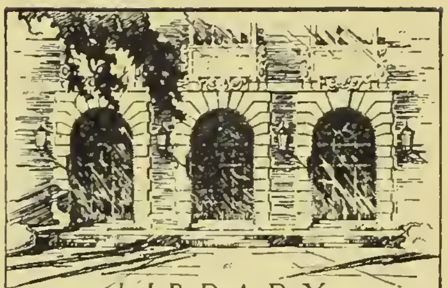

THE POTENTIALITIES OF REVEGETATING AND UTILIZING AGRONOMIC SPECIES ON STRIP MINED AREAS IN ILLINOIS.

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A PROGRESS REPORT
COVERING THE FIRST YEAR OF WORK ON A COOPERATIVE INVESTIGATION
CONDUCTED BY

UNIVERSITY OF ILLINOIS, AGRICULTURAL EXPERIMENT STATION
AND
ILLINOIS COAL STRIPPERS ASSOCIATION.

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<u>NOTE</u>

The agreement covering this investigation provides that:- "No account of a cooperative research project shall be published by the sponsor or by any other agency, except upon approval of the division of the University, or head of the department in which the work is being done."

Permission for the reproduction of this report has been granted with the understanding that it is to be released for the confidential information of members of Illinois Coal Strippers Association only, and not to be quoted or released for publication.

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VICE PRESIDENT

JAMES W. BRISTOW
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FOREWORD

To Members of Illinois Coal Strippers Association.

Gentlemen:

Successful experiments in converting spoil banks to profitable stock range pioneered by Messrs. A. H. Truax and Byron Somers on land mined by Truax-Traer Coal Company near Canton, Illinois, have shown that where top soils on spoil banks are adaptable, the establishment of stock range is the most economical and most highly productive method of returning mined land to productivity.

In 1945 a number of our companies, encouraged by the success of Messrs. Truax and Somers, seeded large areas of their spoil banks with grass and legumes. The varying and sometimes discouraging results obtained, indicated that the successful development of pastures on the widely varying top soils encountered throughout the state, and sometimes within the same mining operation, was a problem for scientists in the fields of agronomy and animal husbandry. Furthermore, that large savings in development costs could be made and better results obtained by operators desiring to rehabilitate their stripped holdings in this fashion, if the problem were approached on a scientific basis.

In January, 1947, the President and Secretary of Illinois Coal Strippers Association were authorized to enter into an agreement with the Agricultural Experiment Station, University of Illinois, covering a cooperative research project, estimated to require five years for completion, designed to thoroughly explore the subject and to develop the highest potential uses of mined land, the types of forage grasses best adapted to the soils and conditions encountered, and all other facts essential to pasture and other forms of use for spoil banks.

The Central States Forest Experiment Station, U.S. Forest Service, agreed to assist in the project by making available for analysis several thousand soil samples collected by its employees engaged in a study of forestation possibilities of spoil banks, and is also listed as one of the cooperators.

The agreement with the University of Illinois, executed for a one-year period beginning February 1, 1947, and renewable each year at the option of Illinois Coal Strippers Association was again renewed for a one-year period as of February 1, 1948. The cost of this project will average about $5,800 annually.

The scope and plan of the project, and the obligations assumed by the partcipants, quoted from the agreement are as follows:

"ILLINOIS AGRICULTURAL EXPERIMENT STATION

Agronomy Project No. 1003
Forestry Project No. 1001

NAME: Agronomic Land Use Research on Stripped Coal Lands in Illinois.

OBJECT: The objectives of this project are to investigate the potentialities of revegetating and utilizing agronomic species on the strip mined areas in Illinois.

FUNDS: Trust and State.

LEADERS: A. L. Lang, R. F. Fuelleman, J. N. Spaeth, and F. C. Francis.
Advisory Committee: Dean H. P. Rusk, W. L. Burlison, F. C. Bauer, J. C. Hackleman, J. N. Spaeth, J. W. Bristow, and Louis S. Weber.
Agronomist: Alten F. Grandt.

COOPERATORS: Illinois Coal Strippers Association.
U.S. Forest Service.
University of Illinois, Departments of Agronomy, Forestry and Animal Husbandry.

STATEMENT OF PROBLEM:

Figures indicate that there are at least 72,100 acres of strippable coal lands in Illinois, of which approximately one-half have already been mined. The development of strip mined areas is first of all a land-use problem including costs and returns affecting its revegetation. Revegetation is especially desirable because strip mining is generally looked upon by the public as seriously affecting the local economy. Although this is not necessarily true, the psychological and esthetic implications of large strip mined areas in a community make it incumbent on the mining companies to provide some means of utilization.

Owners recognizing their obligation to the public have already taken steps to provide means for better use of the mined areas. State and federal agencies have cooperated in reforestation, wild-life management and recreational projects in some areas; however, little work on revegetation with forage species has been attempted. The mining industry has expressed an interest in research of an agronomic nature, involving the establishment of forage species on mined areas, and has appropriated the sum of $6,000 for research. The following problems will be investigated:

1. The physical and chemical characteristics of the soils in the various mine areas of the state.

2. Forage species already established by either artificial or natural means.

3. Adaptation of species with respect to:-
   a. Soil reaction.
   b. Mineral content of the soil.
   c. Physical structure.
   d. Climate.
   e. Moisture.
   f. Time and method of seeding.

4. Adaptation of species as affected by soil amendments:-
   a. Correction of soil reaction.
   b. Mineral deficiencies corrected or balanced.
   c. Physical structure as changed by mining operations.
   d. Moisture and erosion qualities as affected by mulching.

5. Forage yields and quality as determined by:-
   a. Weight of forage.
   b. Chemical composition.
   c. Botanical composition.
   d. Animal gains.
   e. Observations.

6. Economic interpretations:-
   a. Methods and feasibility of forage species establishment.
   b. Costs of establishment.
   c. Accessibility after establishment.
   d. Financial returns.
   e. Evaluation.

7. Dissemination of information:-
   a. Radio - local.
   b. News items - local.
   c. Circulars.
   d. Scientific publications.
   e. Bulletins.

PLAN OF PROCEDURE:

The various departments of the Illinois Agricultural Experiment Station will be responsible for those phases of this project which come within their spheres of interest.

A. Since the preliminary reconnaissance will be worked out by the U.S. Forest Service, the Department of Forestry of the University of Illinois will coordinate the information and data made available by the U.S. Forest Service, which has already begun work. This includes mapping of stripped lands and preliminary classification on the basis of reaction, chemical composition, physical

structure, etc.

1. The U.S. Forest Service also plans reconnaissance on ground cover with respect to forage crops. In so far as possible, the agronomist in charge of the detailed work of this project will cooperate in that survey.

B. The Agronomy Department will be responsible for:

1. Conducting such further surveys as are necessary to determine the nature, quantity, and quality of forage crops now established. These species will be located on appropriate maps, properly labeled with respect to the nature of the environment. Records of previous seedings and their disposition will be recorded. Where any records of animal production are available notations will be made. All records will be kept separately by ownership, counties, townships, sections and subdivisions of sections.

2. Species adaptation studies will be established on spoil banks representative of the various soil classifications and climatic ranges. Seedings, alone and in mixtures, will be made of all species reasonably suited to the area to determine:

a. The most favorable mixtures and pure seedings for rapid growth, survival and longevity.
b. Specific persistence and aggressiveness.
c. Tolerance for soil reaction, mineral content and texture.
d. Speed of establishment in relation to physiographic and ecological factors.

3. Soil amendments will be used in connection with forage adaptation tests and in relation to basic information secured for the specific area concerning reaction, mineral content, physical structure, moisture relationships, and erosion problems. This will require:

a. Soil testing for acidity and plant nutrient content.
b. Corrective measures on acid or alkaline areas.
c. Supplying nutrient deficiencies or balancing supersufficiencies.
d. Modification of physical structure by mining operations or other artificial means.
e. Controlling moisture relationships and erosion influences by the use of mulching materials.

4. Determinations of forage species, production and quality will be made by several criteria, including:

a. Measurements of forage yields in terms of dry matter on established plots or fields. Sampling must be

adequate for accurate determinations.

b. Chemical analysis of forage species samples obtained from various locations and from established experimental areas will be made. This will supplement information made available through the reconnaissance survey.

c. Botanical analysis will be made as a part of the yield determinations chiefly as a basis for cataloging sources of contributions of chemical components and also for animal gains.

5. While it is expected that each area owner will need to interpret the practical applications of this research into his own economy, nevertheless, information will be secured on:

a. Methods of forage species establishment and their utility.

b. Costs involved in such establishment.

c. Useability or accessibility after establishment.

6. Results secured by this investigation will be made available insofar as their practicability warrants, through local radio and news items and by circulars, bulletins, and scientific publications.

C. The Animal Husbandry Department will, after the vegetational phases have been developed, be responsible for:

1. Suggesting the type of livestock for pasturing experimental areas.

2. Measurements of animal weights as a method of determining forage yields.

3. Costs and returns attending livestock operations.

D. The Illinois Coal Strippers Association, through its membership, will provide equipment, seeds, and such manpower on each experimental area sufficient to assist, facilitate, and supplement the work of the agronomist. The above will be in addition to the budgetary item as listed under 'approximate cost.'

To carry out the details of this project will require the efforts of one full-time man well trained in agronomy retained by the University. In addition, agronomy staff members responsible will need to give considerable time to the project in an advisory and directive capacity.

Office space, supplies and equipment, as well as laboratory space and equipment, will be supplied by the Agronomy Department.

Transportation facilities (car) and travel expense will be a large item in the conduct of the field work.

Assistance in making chemical analyses will be needed in the form of student or graduate student help."

A report prepared by the University of Illinois covering accomplishments made on the project during the first year of operation is herewith transmitted for information of our member companies.

Secretary-Treasurer.

Chicago, Illinois
March 10, 1948.

AGRONOMIC LAND USE RESEARCH ON AREAS STRIP MINED
FOR COAL IN ILLINOIS.

According to the data published by the Illinois Coal Strippers' Association 32,056 acres of land were mined by association member mines in Illinois as of June 1, 1946. An additional 40,034 acres is held by member companies to be mined, giving a total of 72,090 acres of land. An analysis of soil cropping potentials derived from the Soil Survey Division of the University of Illinois indicates that about 16.8 percent of these holdings is high grade farm land; 35.2 percent is of medium grade; and the remaining 48 percent consists of forested, rough, or eroded soil not adaptable to general farming purposes. There are 31,600,000 acres of land in the State of Illinois now used for agricultural and farming or forestry purposes; of which less than one-fourth of one percent will be strip mined.

Location of Present Day Industry in Illinois:

Strip coal land mined or held for future mining in Illinois is located in twenty-two counties with major operations being carried on in fourteen counties. The largest mining areas are located in Perry and Fulton counties, in which 5.0 percent and 2.7 percent respectively, of the total county areas are mineable by stripping methods. These general areas are shown on Fig. 1 which also shows the approximate locations of experimental seeding plots established for study under this project.

Description of Mined Areas:

The physical and chemical properties of the spoil material are dominated by the character of the geologic strata from which the spoil is derived. In southern Illinois the amount of loess in the overburden varies from an average of approximately 12 feet in St. Clair to less than 3 to 4 feet in Saline County. Glacial till or drift lies under the loess and varies in thickness

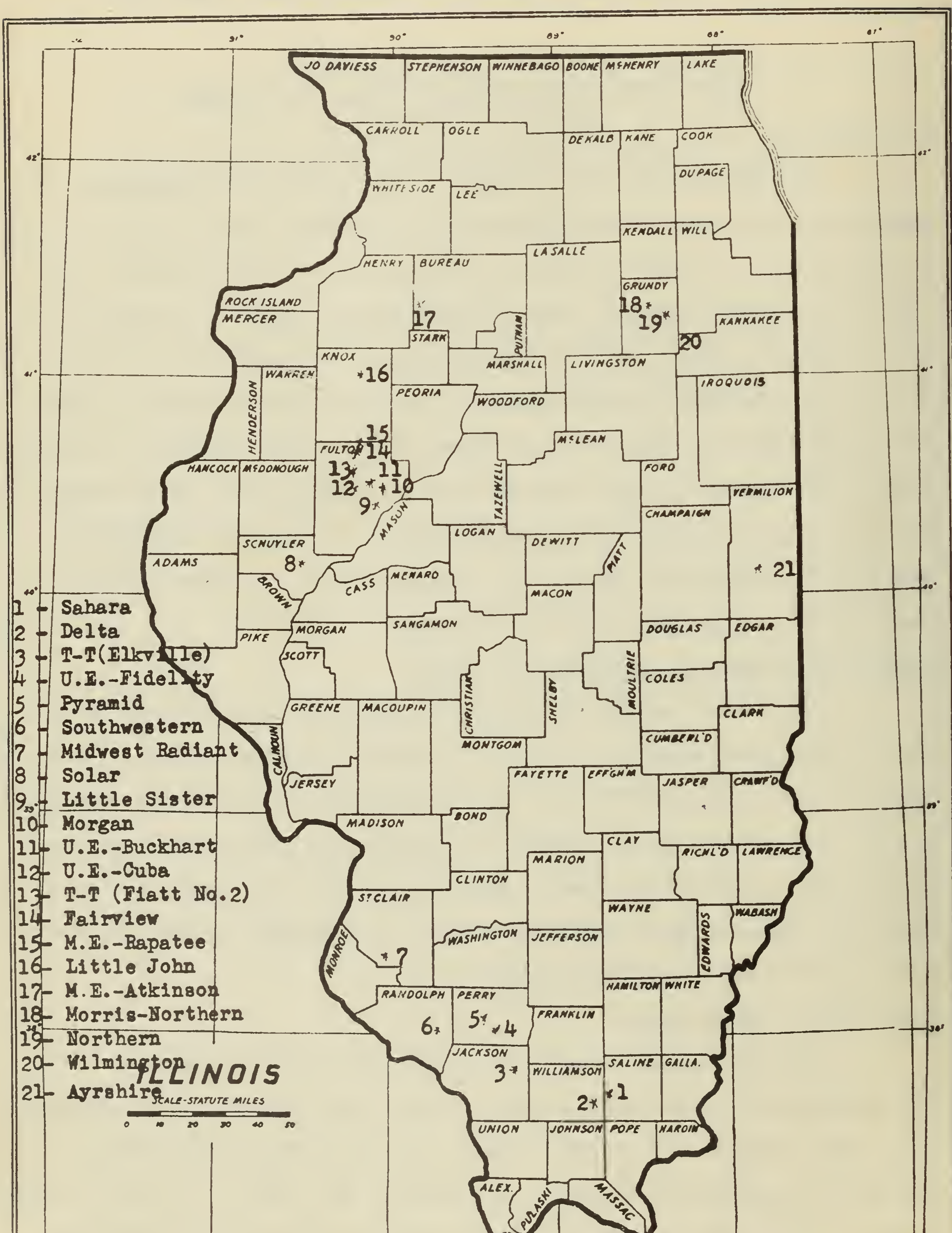

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Fig. 1--Location of Experimental Plots on Strip Mined Coal Lands of Illinois.

from 5 feet to 15 feet in some areas. Soft mud shales and rock make up the remainder of the strata overlying the coal seam. In areas where the percentage of loess in the spoils is highest, the physical condition of the spoil bank material is most friable and from this standpoint the better material on which to get grasses and legumes established. There are some areas where pyritic roof shales are present in sufficient quantities to form localized acid spots.

In western Illinois the amount of loess averages 8 to 10 feet in thickness throughout the area studied. In a few places carbonates have been found at a depth of 6 to 8 feet. The pH of spoil material in this area generally tests above pH 7.0. The spoil banks are predominantly friable and hold moisture readily.

In northern Illinois the overburden is composed largely of sands and shales. These mud shales often weather into heavy impermeable plastic materials which give rise to high runoff and deep gully erosion. Revegetation of such areas is generally slow and may require time for weathering to change the adverse physical conditions to a more favorable state for plant growth. There are other areas in this territory, however, where excellent growth of sweet clover is flourishing.

Soil Analysis:

Table 1 shows the average amounts of soil nutrients, p-H, available phosphorus and available potassium, of spoil bank material. Samples were selected at random from the experimental plots and tests were made by the soil testing laboratory at the University of Illinois. The average p-H of the 684 samples tested was 6.8, the average available phosphorus content was 122 pounds, and the average available potassium was found to be 166 pounds per acre. The plots located in southern Illinois are lower, on the average, in plant nutrients than the overall average, while those in western Illinois are substantially

Table 1. Soil Analysis of Spoil Bank Materials.

Plot locations	County	Samples No.	pH* Av.	P* Av.	K* Av.	Notes
Southern Illinois:						
Sahara	Saline	30	4.9	107	188	S. S. rock.
Delta	Williamson	28	7.0	97	108	
Truax-Traer, Elkville	Jackson	20	6.3	58	155	Local acid spots.
United Elec. Fidelity	Perry	28	6.0	124	198	Local acid spots.
Pyramid	Perry	27	7.4	86	123	Calc. rock.
Southwestern	Randolph	28	7.3	85	137	Calc. rock.
Midwest Radiant	St. Clair	175	7.1	116	131	
Sub-total -		336	6.57	96	149	
Western Illinois:						
Solar	Schuyler	12	6.8	171	224	High % Loess.
Little Sister	Fulton	12	7.2	114	145	In western Ill.
Morgan	Fulton	10	7.1	178	230	
United Elec., Buckhart	Fulton	20	7.7	94	143	
United Elec., Cuba	Fulton	15	7.6	140	143	
Truax-Traer, Fiatt	Fulton	50	7.9	147	145	
Fairview	Fulton	20	6.0	128	186	
Mid. Elec. Rapatee	Fulton & Knox	64	7.4	164	180	
Little John	Knox	26	7.3	167	164	
Sub-total -		229	7.2	145	173	
Northern Illinois:						
Mid. Elec., Atkinson	Bureau	20	7.4	165	192	Shaly material.
Northern Illinois	Grundy	49	6.9	166	219	Shaly material.
Morris	Grundy	28	3.1	84	144	Highly acid.
Wilmington	Will	22	7.7	55	161	Compact & plastic.
Sub-total -		119	6.3	118	179	
TOTAL -		684	6.8	122	166	

*pH - 7.0, neutral; P - 92+ lbs/a, high; K - 150-200 lbs/a high.

higher. In northern Illinois the spoil bank material is more variable. On plots located on property of the Morris Coal and Mining Company the average p-H is 3.1, low enough to be toxic to most plants.

Caution should be used against placing too much emphasis on the averages obtained because of the extreme variability of the spoil bank material. In small local spots the p-H may be low enough to be toxic to plants, and little or no vegetation is found on these localized spots. In other areas, such as sandy spots the available potassium may be less than 40 pounds per acre which would result in poor plant growth. However, in general the soil analysis would indicate very favorable planting sites for most grasses and legumes.

Revegetation Project:

The objectives of this project are to investigate the potentialities of revegetating and utilizing agronomic species on the strip mined areas in Illinois. Revegetation is especially desirable because strip mining is generally looked upon by the public as seriously affecting the local economy. Although this is not necessarily true, the psychological and aesthetic implications of large strip mined areas in a community make it incumbent on the mining companies to provide some means of utilization. Judging from economic returns realized by owners who are utilizing spoil banks, these areas may be considered an asset to the community rather than a liability. It would appear to be a lost resource if they are not utilized to their fullest advantage.

Funds to begin work on this project were made available to the University February 1, 1947. Because of the extremely cold, wet spring, much difficulty was encountered in trying to make spring seedings. Difficulty in locating readily accessible areas on spoil banks for the establishment of experimental plots also prevented making extensive spring seedings. Nevertheless, a number of experimental plots were established, and a number of spring seedings were made.

The early summer was spent in touring the various mined areas with Mr. Louis Weber, Land Use Engineer of the Illinois Coal Strippers' Association, who arranged for meetings with company officials on whose properties more experimental plots are to be located. Observations were made of species already growing on spoil banks and results recorded. Approximately 1,000 plots of various sizes were staked out on areas selected for experimental sites.

Plot Design and Field Methods:

Experimental plots have been laid out on 21 different locations in 14 counties to determine the adaptation of legumes and grasses on various types of spoil materials over the climatic range of Illinois. Forage species are being tested alone and in associations of grasses and legumes in an effort to determine the most desirable method of obtaining a satisfactory establishment.

The plot design employed for the non-leveled spoil banks is shown in Fig. 2A. This design is similar to that used by Tyner*, et al, in their work in West Virginia. The grasses are seeded up and down the slopes to cover at least two complete spoil banks wherever possible. The legumes are seeded across the grass plots and run approximately parallel to the ridges and valleys. The species seeded are randomized in all cases and this plot is duplicated on all properties. This type of arrangement makes possible the study of 64 grass-legume associations. Where the forage species are seeded alone, the plot is 15 feet wide and 145.2 feet long, giving a plot size of one-twentieth of an acre.

The fertility study consists of adding nitrogen in various amounts to grass plots. This design is shown in Fig. 2A by the grass plot seeded alone as exemplified by big bluestem. No fertility treatments are carried out on legume plots at this time since the soil tests show adequate plant nutrients in most cases with the exception of nitrogen, which inoculated legumes can get from the atmosphere. Work of this nature will be investigated further.

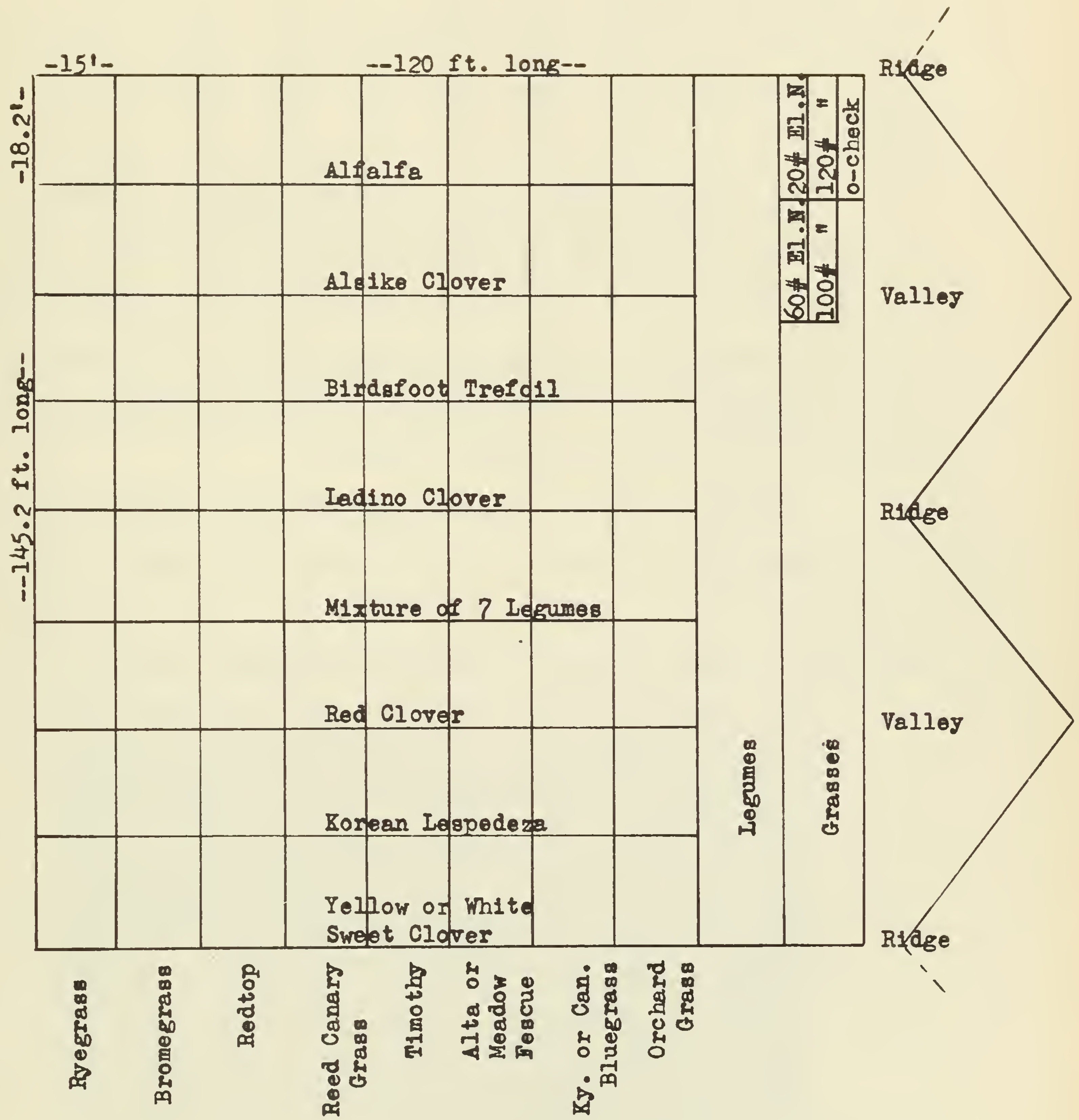


Fig. 2-A.--The plot design used in studying specie adaptation, alone and in association.

The grasses and legumes are seeded by hand with a horn seeder. Fig. 3 shows the actual seeding operation. The two white string lines show the width of the plot and the method of giving plot boundary while the seeding operation is being done. It is realized that this method is not 100 percent accurate, but it was a practical way of seeding the plot without getting too far off the designated area.

The forage species used on these spoil banks are given in Table 2. It is realized that some of the species may not be practical for the owner to use, but in this study an attempt is made to get these species established to obtain observations of the comparative aggressiveness and persistence of the various species. In some areas obtaining a ground cover of any material is an important factor from an aesthetic viewpoint.

Plots have also been established on leveled areas and on strike-off areas. These plots are small, being 1/400 and 1/200 acres in size (Fig 2B). A comparison will be made between the two types of plots in regard to percent germination, percent growth of seedling to maturity, ground cover, yields, and other factors. These plots are shown in Fig. 4-8. Leveled plots are located in southern Illinois on Midwest Radiant Corporation property, in St. Clair County; in western Illinois on Midland Electric Coal Corporation, Rapatee Mine, in Knox County; and in northern Illinois on Northern Illinois Coal Corporation property, in Grundy County. "Strike-off" plots are located on Midwest Radiant Corporation property in St. Clair County. It is hoped that strike-off plots can also be located and established in western and northern Illinois.

Plots were also located on drag-line leveled spoils in Saline County on Sahara Coal Company property on which second-year sweet clover had been growing and had gone to seed. Fourteen grasses have been seeded in duplicate on this location. It is thought that the sweet clover has formed enough humus and collected nitrogen for the support of these grasses. More plots will be

--5'--

--21.5'--

0-N check	20 pounds elemental nitrogen	40 pounds elemental nitrogen	60 pounds elemental nitrogen	80 pounds elemental nitrogen	100 pounds elemental nitrogen	120 pounds elemental nitrogen	400 pounds 8-8-8

The plot design used on leveled areas and for different levels of nitrogen applications on wheat and rye, etc. Plots 1/400 acre. (Fig. 2-B)

Photograph showing seeding operation. The lines in center of picture mark boundary of the plot being seeded. (Fig. 3)

Table 2. Forage Species To Be Seeded.

Grasses

Common Name	Botanical Name
Kentucky bluegrass	Poa pratensis
Canada bluegrass	Poa compressa
Redtop	Agrostis alba
Timothy	Phlem pratense
Reeds canary grass	Phragmites communis
Orchard grass	Dactylis glomerata
Bromegrass	Bromus inermis leyss
Meadow fescue	Festuca pratensis
Alta fescue	Festuca pratensis var. alta
Chewings fescue	Festuca rubra
Creeping fescue	Festuca rubra var. creeping
Ryegrass	Lolium perenne
Bermuda grass	Cynodon dactylum
Dallas grass	Paspalum notatum
Crested wheat grass	Agropyron cristatum
Slender wheat grass	Agropyron tenerium
Western wheat grass	Agropyron smithii
Blue grama	Bouteloua gracilis
Side-oat grama	Bouteloua curtipendula
Big bluestem	Andropogon furcatus
Little bluestem	Andropogon scoparius
Buffalo grass	Buchlae dactyloides
Indian grass	Sorghastrum nutans
Tall oat grass	Arrhenatherum elatius
Canadian wild rye	Elymus canadensis
Michael's grass	
Rhodes grass	Chloris gayana
Switch grass	Panicum virgatum
Meadow foxtail	Alcopecuris eliator
Millets	Setaria sp.
Sudan	Sorghum halapense
Sweet sudan	(Cross) Sorghum halapense x S. vulgare
Love grass	Eragrostis curvula
"M" pasture mix	
Fields pasture mix	
	Calamagrostis epigea
Wheat	Triticum aestivum
Oats	Avena sativa
Rye	Secale cereale

Table 2, (cont'd) - Forage Species To Be Seeded

Legumes

Common Name	Botanical Name
Alfalfa	Medicago sativa
Sweet clover - yellow	Melilotus officinalus
Sweet clover - white	Melilotus alba
Hubam clover	Melilotus annula
Spanish sweet clover	Melilotus suaveolus
Lespedeza - common	Lespedeza striata
Lespedeza - Korean	Lespedeza stipulacea
Lespedeza - Kobe	Lespedeza striata var.
Lespedeza - Sericea	Lespedeza sericea
Mammoth clover	Trifolium pratense var. perenne.
Alsike clover	Trifolium hybridum
Crimson clover	Trifolium incarnatum
Subterranean clover	Trifolium subterraneum
Strawberry clover	Trifolium fragiferum
White Dutch clover	Trifolium repens
Ladino clover	Trifolium repens var. latum
Hop clover	Trifolium procumbens
Alyce clover	Trifolium alyce
Austrian winter pea	Pisum sativa var.
Birdsfoot trefoil	Lotus corniculatus
Big broadleaf trefoil	Lotus uliginosus
Yellow trefoil	Medicago lupulina
Kudzu	Pueraria chunbergiana
Lupines	Lupinus sp.
Lappacea	Trifolium lappaceaum
Soybeans	Glycine max.
Red clover	Trifolium pratense
Sanfoin	Onobrychis vicioefolia
Crown vetch	Vicia sp.
Button clover	Medicago oebicularis
Persian clover	Trifolium reseysinatum

Character of material after leveling, showing plots staked out in background. Midland Electric Coal Corporation Rapatee mine. (Fig. 4)

Northern Illinois Coal Corporation. Leveled area - wheat plots with various amounts of nitrogen fertilizer added. (Fig. 5)

A spoil ridge after "strike-off" operation has been completed. (Fig. 6)

Strike-off area seeded to rye and wheat. (Fig. 7)

Rye and wheat growing on strike-off ridge. (Fig. 8)

established this next summer on spoils on which sweet clover has been growing the second year so that this type of association can be studied more thoroughly.

A mixture of five legumes (alfalfa, yellow sweet clover, alsike, mammoth clover, and birdsfoot trefoil) with perennial ryegrass was seeded under trees on plots established by the Central States Forest Experiment Station on Little John Coal Company and Wilmington Coal Company properties. These plots are 300 feet long and 112 feet wide, making approximately 0.8 acres. This area covers six ridges or hills, giving a total of 12 slopes with six northerly and six southerly exposures.

Results and Discussions:

Because of the limited amount of spring seeding accomplished, yield data and chemical composition of forage species are very limited at this time.

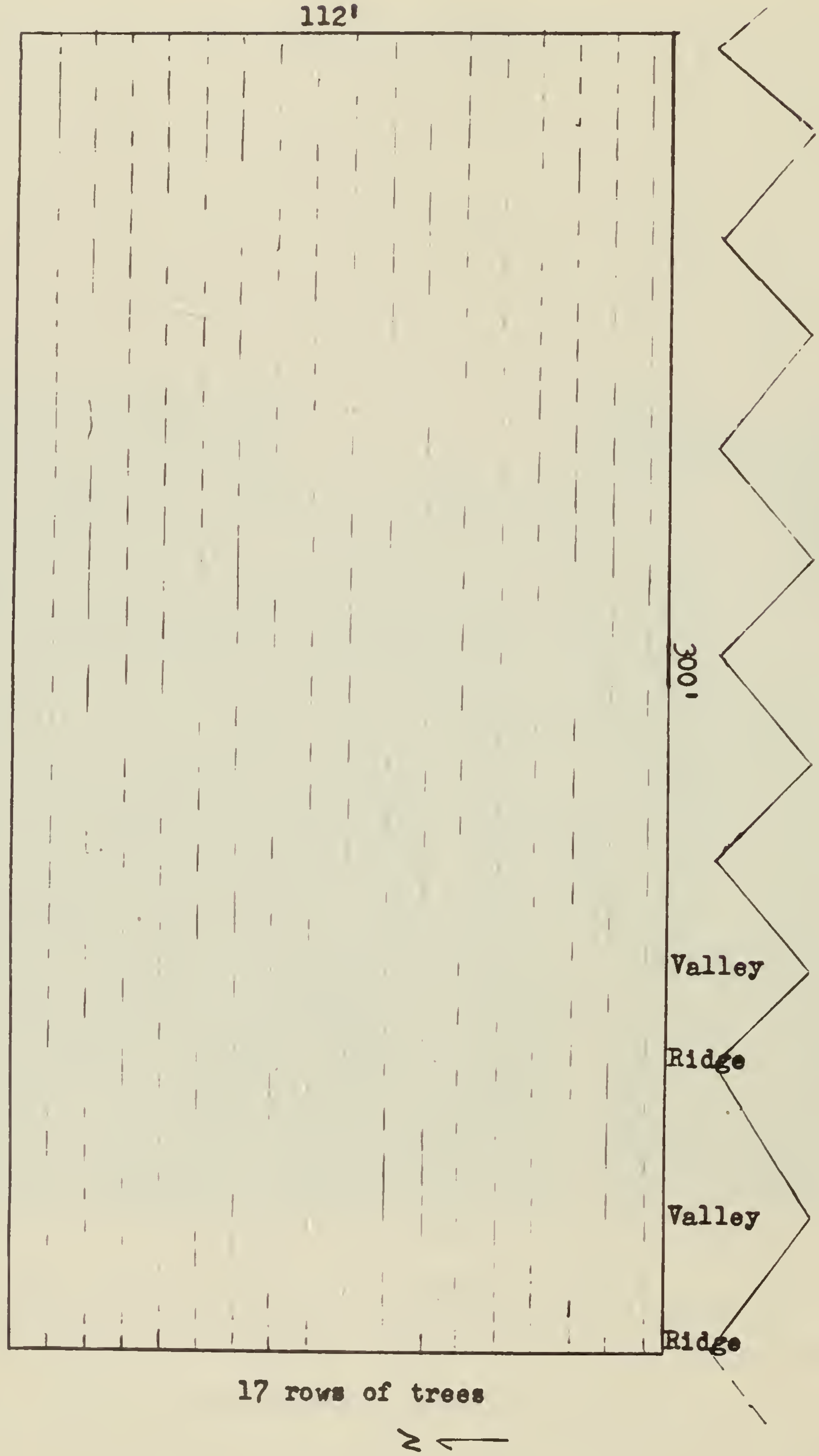
1. Grass-Legume Mixture On Little John Coal Company, Knox County (Fig. 2C)

A mixture of

ryegrass	- 5 lbs.	mammoth clover	- $1\frac{1}{2}$ lbs.
alfalfa	- 2 lbs.	alsike clover	- 1 lb.
yellow sweet clover	- $2\frac{1}{2}$ lbs.	birdsfoot trefoil	- 1 lb.

making a total of 13 pounds seeded April 17, 1947 on two 0.8-acre plots on which trees had been planted. The legumes were inoculated, mixed together, and seeded with a horn seeder. The ryegrass was spread by hand. On June 9, 1947 seedling counts were made. A one-foot square was used. Four areas were selected at random on both plots. On plot 9, 38 percent of the ryegrass seeded germinated and grew, and 44 percent of the legumes grew. On plot 10, 56 percent of the ryegrass and 30 percent of the legumes that were seeded grew. Later observations were very striking. The ryegrass grew rapidly and seemed to predominate; however, a good stand of legumes was present the entire summer. A thicker stand and better ground cover was obtained on north exposure slopes than on southerly exposure slopes. It was also noted that the top two or

(Fig. 2-C) Plot Design of Tree-Grass-Legume Mixture



three feet of the peaks were not covered. Yield samples taken in August gave a yield of 4.34 tons of forage per acre. Not enough yield samples were taken to make this an accurate figure, but it gives an indication of what yields may be expected. The greater percentage of forage was ryegrass. The ryegrass had already gone to seed and was beginning to dry when the samples were cut.

From the above data it will be noted that less than one-half of the seed that was seeded germinated and established itself. Because of the slope, in all probability much of the seed was washed off the slopes before the seeds could germinate and become anchored. Thus it seems evident that a heavier seeding should be used than that normally recommended in farming practices; also, there is probably an ideal time to seed the species to result in a minimum washing away of the seed. This factor is important. Alternate freezing and thawing will aid in partially burying the seed and thus hold them better so probably seeding should be made earlier than these plots were seeded.

2. Grass-Legume Mixture on
Wilmington Coal Mining Company, Will County.

On the Wilmington Coal Mining Company plots where the same mixture was seeded, the results are quite opposite from those obtained on the Little John property. Seedling counts made show a variation in the percentage germination. Plot 27 showed 90 percent ryegrass and 26 percent of the legumes germinated, while on plot 28, 26 percent of the ryegrass and 6 percent of the legumes germinated. It was noted, however, that many of the seedling roots were exposed. The roots could not penetrate the compact surface material of the spoils. Later observations were that the legumes had died out completely, and in some of the gullies a few sprigs of ryegrass were struggling for their existence, but it had all disappeared on other places. Scattered clumps of Russian thistle are growing on these plots.

The physical condition of the materials exposed by the stripping

operation on these plots is very compact and plastic, and undoubtedly is the factor limiting the establishment of a satisfactory stand of forage species. The soil tests show sufficient amounts of available phosphorus and potassium and a favorable pH for the growth of legumes. Perhaps a period of weathering is required to change the physical condition to such extent that grasses or legumes can be established. More work is being carried on in these areas to further study these problems.

The extent of gully erosion that occurs on this type of spoil bank is shown in Fig. 9. It will be noticed that the slope of the banks is still quite steep.

3. Kudzu Adaptation.

Kudzu crowns were planted on plots in western and southern Illinois. Very few crowns lived through the summer. It is believed that the cuttings dried out too much in shipping and were not satisfactory stock for planting. More crowns will be planted this spring to determine the adaptation of Kudzu to the spoil banks.

4. Fertility Plots (Fig. 2-D)

Fertility studies with respect to nitrogen were conducted on Midwest Radiant Corporation property with four grasses, -- orchard grass, meadow fescue, sweet sudan, and white wonder millet. Where no nitrogen was added, the grass came up in scattered spots but soon died. When 120 pounds of elemental nitrogen or Uramon was applied per acre, scattered spots of thick, dense stands were secured. The nitrogen increased the weed growth to such an extent that in some places the grass was probably crowded out. It was noted that this nitrogen treatment increased the size of cottonwood leaves, in some cases quadrupling their size. Fig. 10 shows the effect of the nitrogen on weed growth.

Samples were collected from these plots and chemical analyses will be run. The stand was so very spotted that yield data were not taken. The banks

Photo showing nature and extent of gully erosion on spoil banks of Wilmington Coal & Mining Company. (Fig. 9)

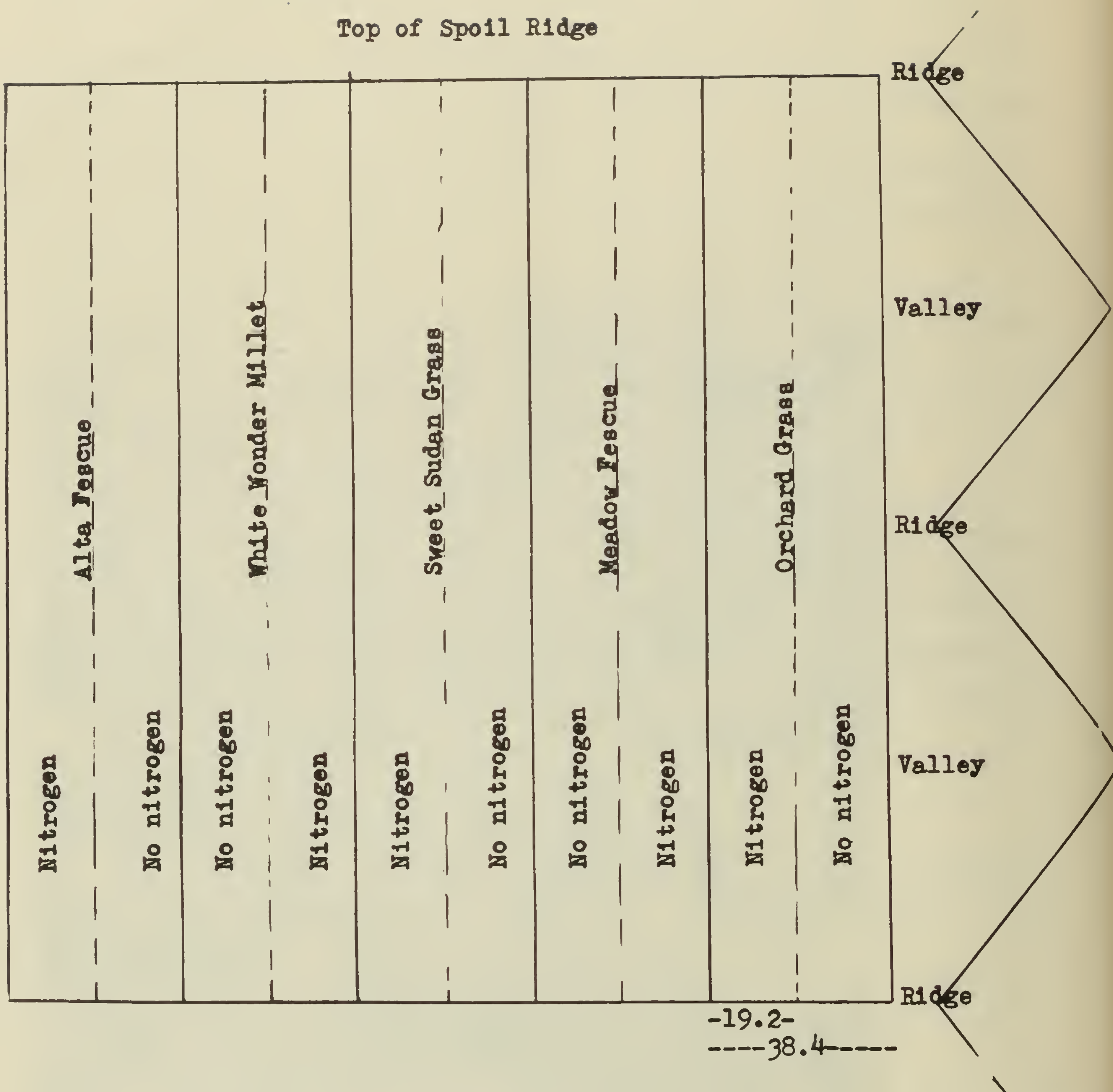


Fig. 2-D. Plot design of fertility studies with five grasses on Midwest Radiant Corporation property.

Effect of nitrogen on weed growth on Midwest Radiant Corporation property. (Fig. 10)

in this area were very steep, averaging 56 to 60 percent slope, and gully erosion was so severe that seeds were washed away before they could become established.

5. Fall Seedings of Species Alone and in Association.

Fall seedings were made in southern Illinois on the following properties: Midwest Radiant Corporation, St. Clair County; Sahara Coal Company, Saline County; Southwestern Illinois Coal Corporation, Randolph County; and on the Truax-Traer Coal Company, Jackson County. Excellent prospects of the species seeded were observed on Southwestern and Midwest Radiant properties, and on the northern exposure of the plots on the Truax-Traer Coal company property in Jackson County.

In western Illinois seedings were made on the Little Sister property on a heavy growth of weeds. Because of the very heavy growth of weeds, very few seedlings of the species seeded could be found this fall. Fall seedings were also completed on the Little John Coal Company property.

In northern Illinois plots were seeded this fall on the Northern Illinois Coal Corporation and Wilmington Coal Mining Corporation properties. In checking over the areas seeded, no seedlings were found. The fall was exceptionally dry, and perhaps some growth will take place in the spring. Fig. 11 shows the nature of spoil bank material in this area on Northern Illinois Coal Corporation property.

Plots were also established on leveled areas and on strike-off areas. Wheat and rye were seeded and different applications of nitrogen were applied. Observations have been recorded and studies will be continued. At this time it can be said that the wheat and rye germinated satisfactorily and in most cases went into the winter period in good condition. Forage species are also seeded on these areas.

Nature of spoil bank material on Northern Illinois Coal Corporation property. (Fig. 11)

Plans for the Coming Year:

A field trip is being planned on which farm advisers of counties in which strip mining is being carried on, personnel from the various companies interested in establishing satisfactory forage pastures, and other interested persons will be invited. They will have an opportunity to observe the results obtained on the plots established and perhaps observe what private individuals have accomplished, and thus get information as to what use the spoil banks can be made.

Plans are being made to measure animal weights as a method of determining forage yields. Comparisons will also be made of forage quality and yields on (1) spoil banks, (2) improved pastures, and (3) average pastures of an area. This will be carried on in different climatic ranges, such as Western Illinois (Fulton County) and Southern Illinois (Perry County).

Seedings will be made this winter and spring on the remainder of the 1,000 odd plots not seeded this fall. Native grasses, as Big Bluestem, Indian grass, etc., will be seeded in January and February. The common grasses and legumes will be seeded in February, March, and April.

Samples of forage will be taken to determine the chemical composition of the forage species grown. Adequate randomized samples will be collected to determine the yields of forage obtained. The relative percentages of various grasses, legumes, and foreign material will be estimated. This type of work is to be carried on as a follow-up to last year's seedings and to seedings made in the fall and spring of 1947-48.

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*Tyner, E. H. The reclamation of the strip-mined coal lands of West Virginia with forage species. Soil Sci. Soc. Amer. Proc. 10:429-436. 1945.

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THE POTENTIALITIES OF REVEGETATING AND UTILIZING
AGRONOMIC SPECIES ON STRIP MINED AREAS
IN ILLINOIS.

- - - - - - - - -

A PROGRESS REPORT
COVERING THE SECOND YEAR OF WORK ON A COOPERATIVE INVESTIGATION
CONDUCTED BY
UNIVERSITY OF ILLINOIS, AGRICULTURAL EXPERIMENT STATION
AND
ILLINOIS COAL STRIPPERS ASSOCIATION.

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NOTE.

The agreement covering this investigation provides that:- "No account of a cooperative research project shall be published by the sponsor or by any other agency, except upon approval of the division of the University, or head of the department in which the work is being done."

Permission for the reproduction of this report has been granted with the understanding that it is to be released for the confidential information of members of Illinois Coal Strippers Association only, and not to be quoted or released for publication.

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FOREWORD

To Members of Illinois Coal Strippers Association.

Gentlemen:

On February 1, 1947, Illinois Coal Strippers Association entered into an agreement with the Agricultural Experiment Station, University of Illinois, covering a project of cooperative research into the possibilities of revegetating and utilizing grasses and legumes on strip mined areas for stock range and other purposes.

This project estimated to require five years of research in order to arrive at sound conclusions, is now entering upon its third year. A progress report covering the first year of operation issued on March 19, 1948 dealt principally with the proposed scope and plan of attack on the problem; a survey of spoil bank soils found throughout the state, and preliminary reports on a number of seeding projects.

The report herewith presented covers the second year of operation. It presents further information on spoil bank soil materials, and comparisons of such materials with surface soils found on adjoining land; the adaptation of various forage species to spoil bank soils; the results of preliminary studies of comparative gains made by animals pastured on spoil banks with those pastured on undisturbed blue grass and highly improved grass-legume pasture.

In addition to continuing work along the above general lines, research in the coming year will be extended to include the measurement of yields per acre, chemical analyses and feed value of various forage species grown on spoil banks in order to determine the carrying capacity of this type of pasture.

James W. Bristow
Secretary-Treasurer

March 15, 1949.

AGRONOMY PROJECT.

NUMBER: 1003 - Second Annual Report.

TITLE: Agronomic Land Use Research on the Mined Areas of the Stripped Coal Lands of Illinois.

OBJECT: The objectives of the project are to investigate the potentialities of revegetating and utilizing agronomic species on the strip-mined areas in Illinois.

LEADERS: A. L. Lang, R. F. Fuelleman, J. N. Spaeth, and F. C. Francis.

Advisory Committee:-

Dean H. P. Rusk
W. L. Burlison
F. C. Bauer
J. C. Hackleman
J. N. Spaeth
James W. Bristow
Louis S. Weber.

Agronomist - Alten F. Grandt.

AGRONOMIC LAND USE RESEARCH

ON STRIPPED COAL LANDS IN ILLINOIS.

By Alten F. Grandt.*

This is the second annual report of progress made on Agronomy Project 1003, a cooperative research project of the University of Illinois Agricultural Experiment Station and the Illinois Coal Strippers Association covering an investigation of the potentialities of revegetating and utilizing agronomic species on strip-mined areas in Illinois.

Some of the material contained in the progress report covering the first year of work will be repeated and in other instances the first progress report will be referred to.

The following problems are being investigated:

1. The physical and chemical characteristics of the soils in the various mine areas of the state.
2. Forage species already established by either artificial or natural means.
3. Adaptation of forage species alone and in mixtures.
4. Adaptation of forage species as affected by soil amendments.
5. Determination of forage yields and quality.
6. Economics of establishing and utilizing spoil banks for pasture.

Note * -- Special Research First Assistant, Soil Experiment Fields and Crop Production, Department of Agronomy, University of Illinois Agricultural Experiment Station, Urbana.

The author acknowledges with thanks the assistance, advice, and encouragement received from Mr. Louis S. Weber, Land Use Engineer, Illinois Coal Strippers Association, in conducting these investigations. Without his help some phases of this work could not have been accomplished.

SOIL STUDIES:

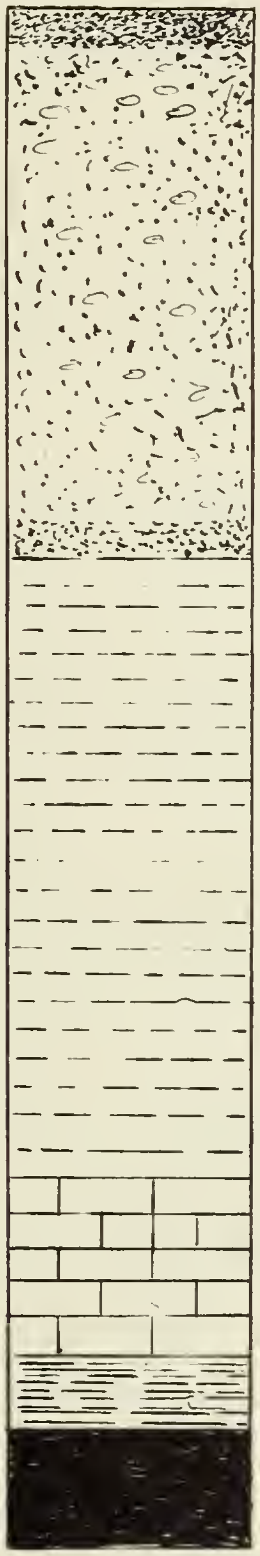
STRATIOGRAPHIC RECORDS:

One method of determining the land use of spoil banks is to study the nature of the overburden above the coal beds. The material which overlies the coal and goes to make up the spoil banks is highly variable both in thickness and in character. It presents a complex of pre-glacial, glacial, and post-glacial material, and no one profile may be given as representative of the overburden within a single mine, much less throughout the stripping fields of the state.

Figure 1 illustrates something of the nature and variations of the strata commonly present. Table 1 shows the depth and percentage of various strata of the overburden. The samples were taken from the highwall in the vicinity where the experimental plots are located. Where the percentage of the loess is high, as in western Illinois, pasture establishment is potentially easier than on soils having smaller percentages of loess. Where the quantity of rock is excessive a use other than pasture should be made of such spoil banks. More preparatory work, such as strike-off, can be done more economically on locations where the rock is more limited.

In 14 counties in which studies of spoil banks are carried on the topsoil and loess, as tested from highwall samples, had an average pH of 6.4; 75 pounds per acre of available phosphorus; and 115 pounds per acre available potassium. Loess is a very desirable soil material because of its silty texture and in general high fertility level.

The glacial till is extremely variable. The Illinoian till is highly leached in most cases and thus is low in plant nutrients. The Wisconsin till is of a younger geologic age and is not highly leached. The average pH of the till tested was 7.3 with 77 pounds of available



0-18'

Top soil - variable.
Loess - depth related to nearness to Mississippi and Illinois Rivers.
$CaCO_3$ present at greater depths.
Sand present in Kankakee River watershed.

5-20'

Glacial till - very variable -
$CaCO_3$ present in Wisconsin till.

3-34'

Shale - gray to blue - generally hard and well-bedded weathers rapidly when exposed.
Generally high in phosphorus and potassium.
pH variable - from 2.5 to 8.5.

0-12

Limestone - characteristic stratum above No. 6 coal - variable.

0-5

Slaty shale - very irregular.

Coal.

Profile of the overburden showing the horizons commonly present in Illinois strip mines. The figures at the left of the diagram represents, in feet, the extremes encountered in samples taken. (Fig. 1.)

Table 1. Average Depth and Percent of Various Strata of Overburden in Highwall

Company	County	Total depth feet	Loess and Surface Soil		Glacial Material		Shale		Rock and Slate	
			Depth feet	Percent of total	Depth feet	Percent of total	Depth feet	Percent of total	Depth feet	Percent of total
Sahara	Saline	45-50	3-4	6	5	10	5	10	24-31	50-70
Delta	Williamson	32	4-6	16	13	41	10	31	4	12
T-T (Elkville)	Jackson	34	6-7	18	8	24	18-20	53	2-0	5
U.E. (Fidelity)	Perry	48	7	15	9	19	30	19	2	4
Pyramid	Perry	44	5	11	11-13	30	23	52	3	7
Southwestern	Randolph	44	7	16	11	25	21	48	5	11
Midwest-Radiant(1)	St. Clair	45	13	30	10	22	10	22	12	26
Midwest-Radiant(2)	St. Clair	34	11	32	19	56	3	9	1	3
Little Sister	Fulton	33	10	30	17	51	6	19	0	0
U. E. Buckheart	Fulton	54	18	33	15	28	20	37	1	2
T-T (Fiatt)	Fulton	40	12	30	12	30	11	28	5	12
Fairview	Fulton	57	12	21	12	21	25	44	8	14
M. E. Rapatee(1)	Fulton	48	12	25	16	34	20	41	Trace	
M. E. Rapatee(2)	Fulton	50-54	9	17	11	21	30-34	32-62	Trace	
Little John	Knox	47	14	30	10	21	17	36	6	13
M. E. Sheffield	Bureau	45	3	7	15	33	24	53	3	7
Northern Illinois	Grundy	47	Sand	23	7	15	24	51	5	11
Wilmington	Will	50	10	20	18	36	22	44	0	0

phosphorus, and 112 pounds of available potassium per acre.

The shales in the overburden were found to be high in available phosphorus and potassium with an average of 148 and 212 pounds per acre respectively. In many instances, the amounts of each element available was greater than could be tested by the photometer. The pH of shales is generally very high. The average was found to be 7.1, with some layers as high as 8.5. However, in some instances the pH was as low as 3.5. A more thorough study of the shales will be made.

Another source of data concerning the nature of the overburden would be the use of drill records. From such records predictions could be made of the physical nature of the spoil bank material and an indication of potential land use. For example, where the percentage of dense clay and soft mud shales is high the spoil banks upon weathering will be very impermeable and subject to severe gully erosion. Such a condition is prevalent in the northern Illinois area. Restricted infiltration and shallow rooting indicate that drouth is a serious factor in establishing vegetation on this type of material. Soil moisture determinations of the surface material give further proof to this point.

The source of sulphur from which the toxic "acid spots" form is not yet definitely known. By studying the stratiographic column, it is hoped that more information on this problem can be obtained. Iron pyrites and marcasite found in the roof coals and black shales is the source of some, but certainly not all, of the sulphur. Croxton (1) points to the shales as a possible source of the acid. This appears evident in that some layers samples in the highwall study revealed pH as low as 3.5. Figure 2 shows acid spots on the spoil banks around which no vegetation will grow. The dark appearing spots are high acidic.

Weathering and subsequent leaching will reduce the total sulphur

Acid spots on spoil banks in Saline County. The dark appearing spots are highly acidic. It has been estimated that less than five percent (5.0%) of all land strip-mined in the state, as of 1946*, is affected by this toxic acid condition. (Fig. 2)

Central States Forestry Experiment Station - 1946.

content of these acid spots. At present it is not known how long a period of time will be required to reduce the sulphur content to the point where normal vegetative growth occurs.

SOIL TYPES BEING STRIPPED:

The type name, number and description, and the productive rating of some of the soils being stripped by each mine for the county are listed in Appendix A. The area stripped was checked, by section, against the recorded soil types published by the Illinois Soil Survey. Where soil reports are available the percent of each type being stripped can be determined.

Appendix B lists the average yield per acre of various crops under different systems of management on some of the soil types being stripped. These yields should be correlated with the productive ratings given for the soil types to determine the true agricultural value of the soil type.

In connection with the yield data Appendix C gives the acre values of crops and indexes for 1944-1947, on soil types listed, as determined from soil experiment field data. This information is listed so as to give a better understanding of the nature of the soil material before and after the stripping operation, and the readers attention is specifically called to the data contained in these appendixes.

SOIL ANALYSIS OF SPOIL BANK MATERIAL:

Table 2 shows the average amounts of soil nutrients, (pH available phosphorus and available potassium), found in spoil bank material. Samples were selected at random from the experimental plots and tests were made by the soil testing laboratory at the University of Illinois. The averages include samples collected in 1947 and 1948. Only minor shifts in the averages resulted, so they would seem to be reliably

Table 2. SOIL ANALYSIS OF SPOIL BANK MATERIAL.

Plot Locations.	County.	No. of Samples.	Acidity p-H* Average.	Phosphorus lbs.* Average.	Potassium lbs.* Average.	Note.
Southern Illinois						
Sahara	Saline	54	4.5	90	169	Shale + S. S. Rock.
Delta	Williamson	52	6.2	86	110	
T-T, Elkville (Truax-Traer)	Jackson	20	6.3	58	155	Local acid spots.
N.E. Fidelity	Perry	60	6.7	145	204	Local acid spots.
Pyramid	Perry	44	7.1	91	154	
Southwestern	Randolph	34	7.3	82	138	Calc. rock.
Midwest Radiant	St. Clair	175	7.1	116	131	
Sub-total -		438	6.6	105	147	
Western Illinois						
Solar	Schuyler	12	6.8	171	224	High percent
Little Sister	Fulton	28	7.7	157	179	Loess in
Morgan	Fulton	10	7.1	178	230	W. Illinois.
U.E.,Buckheart	Fulton	36	7.7	101	134	
U.E., Cuba	Fulton	32	7.5	123	144	
T.T., Fiatt	Fulton	78	7.8	146	148	
Fairview	Fulton	44	6.5	133	167	
M.E. Rapatee	Fulton-Knox	81	7.5	148	177	
Little John	Knox	67	6.8	166	194	
Sub-total -		388	7.3	140	169	
Northern Illinois						
M.E. Atkinson	Bureau	84	7.4	157	264	Shaly material.
Northern Illinois	Grundy	67	6.7	139	198	Shaly material.
Morris	Grundy	28	3.1	84	144	Highly acid.
Wilmington	Will	22	7.7	55	161	Compact and plastic.
Northern Illinois	Kankakee	40	7.6	110	184	Compact and plastic.
Sub-total -		241	6.8	127	209	
Total and averages -		1 067	6.9	122.7	169.2	

*p-H - 7.0 neutral; P - 92 lb/A, high; K150 - 200 lb/A high.

representative. A total number of 1067 samples was tested. The average pH was 6.90; the average available phosphorus content was 122.7 pounds per acre; and the average available potassium was 169.2 pounds per acre. These amounts of nutrients are adequate for good forage production.

The plots located in southern Illinois contain smaller quantities of plant nutrients than the overall state average, while those in western Illinois are substantially higher. In northern Illinois the tests show the spoil bank material to be more variable. In the sandy areas both the available phosphorus, and potassium content are low. In other areas a toxic acid condition exists. These facts emphasize the variability of spoil bank material and suggest that each location be studied individually when planning land use. A systematic sampling technique and the thorough testing of spoil bank soils for acidity, phosphorus, and potassium are the first steps in the detailed planning for the best use to be made of the land.

ANALYSIS OF SOILS TESTED BY COUNTY SOIL TESTING LABORATORIES:

A study was made of soil tests from farms in the counties where strip mining is being carried on. These data were obtained from the county soil testing laboratories. Detailed summaries of the various tests are listed in Appendix C. Table 3 shows a comparison of soil tests on spoil bank soils and soils of farm land. The farm land averages were computed and are not amenable to direct comparisons.

The acidity tests of spoil bank materials were determined by a Beckman pH machine which measures the hydrogen ion concentration or pH of the soil. The acidity tests of the county were made by the Comber test method which enables one to determine the amounts of limestone (in tons) required to neutralize the soil acidity. The correlation between the Comber test and the pH readings is as follows:

Comber tests tons limestone required.	Range in pH for Comber test readings.	Average pH reading used for computed averages.
0-1	7.0-6.11	6.5
2	6.1-5.81	6.0
3	5.8-5.31	5.5
4	5.3-4.71	5.0
5	4.7-4.21	4.5
6	4.2	

The computed averages found in Table 3 were obtained by multiplying the number of samples requiring a definite amount of limestone and using the average pH listed for each limestone requirement as the multiplicand. The products were totaled and divided by the total number of samples to obtain the computed pH averages.

The phosphorus tests made by the county were determined by the improved phosphate soil test developed at the University of Illinois. This gives a blue color, the intensity of which varies with the relative amount of phosphorus available. The phosphorus tests of spoil bank materials were made by the photometer method for determining available phosphorus in soils; the available phosphorus content is recorded in pounds per acre. The correlation between the visual color test and the photometer test is as follows:

Improved phosphate test, color intensity.	Photometer reading pounds per acre.	Average reading used in pounds per acre for computed averages.
Low	20-32	26
Slight	33-53	43
Medium	54-75	65
High	76-92	84

The spoil bank tests were determined by the photometer method, which measures up to 200 pounds per acre of available phosphorus, and the farm samples were run by the color method, which measures a maximum of 92 pounds per acre of available phosphorus. The spoil bank readings

TABLE 3. COMPARISON OF THE AVERAGES OF SPOIL BANK AND FARM LAND SOILS.

County	Acidity average p-H		Phosphorus		Potassium	
	Spoil banks.	Farmland*	Spoil banks.	Farmland*	Spoil banks.	Farmland*
Bureau	7.4	5.80	87.3	40.7	264.0	215.6*
Fulton	7.1	6.01	84.5	46.7	161.7	205
Grundy	5.7	6.14-	71.0	51.7	182.0	208
Jackson	6.3	5.79	53.0	41.0	155	180
Kankakee	7.6	....	79.4	....	184	176.8
Knox	6.8	5.88	88.7	36.1	194	204.9*
Perry	7.1	6.00	79.4	35.1	173.3	158
Randolph	7.3	6.21	68.0	39.1	138	157.7
Saline	4.5	5.79-	73.8	37.7	169	180.1*
Schuyler	6.8	5.85	88.0	33.4	224	155.9*
St. Clair	7.1	6.04	64.0	39.7	131	166
Vermilion	...	5.70	....	56.1	....	206*
Will	7.7	5.47	51.8	49.4	161	225.7*
Williamson	6.2	6.10	61.0	37.4	110	193.4

Farm land soils (tested by the County Soil Testing Laboratories.)

* Computed averages
See Appendix D.

were reduced to a level with the farm samples by taking 92 pounds per acre as a maximum reading. Thus the samples are more nearly comparable than if averages of two different methods of testing were compared. The computed averages were figured in the same manner as the computed pH averages.

The potassium tests of both farm land and spoil bank material were made by the photometer method for the determination of available potassium in soils. Some of the averages from farm land tests are arithmetical averages and thus are directly comparable with the spoil bank tests. Where arithmetical averages were not available computed averages were again determined.

In some cases the number of samples tested for potassium was small and the averages obtained in such counties are not too reliable, because they represent such a small percentage of the county area and undoubtedly include the better farms and the more progressive farmers who practice soil treatment. The averages shown are probably higher than a more representative county average would be.

In all cases the spoil bank soil material tests were higher in available phosphorus than the county farm land averages. In 11 of 13 counties listed the pH of spoil bank soil material was higher than the average pH of county farm lands. The available potassium content of spoil bank soil materials is generally lower than adjacent farm land. One of the reasons for this is that much of the potassium of spoil bank soils is present in an unavailable form. Vegetative growth and weathering will tend to change some of the unavailable potassium to a more available form.

Illinois is one of the few states where soil testing of farm lands is an accepted and widespread practice. These tests were made by the state and county soil testing laboratories. The above comparisons

were made possible from the records made available by these laboratories.

TEMPERATURE AND MOISTURE RELATIONSHIPS OF SPOIL BANK SOILS:

The temperature and moisture of spoil bank soils were measured during July and August on various slope exposures and under varying amounts of vegetative cover. The temperatures on slopes having south or west exposures were higher than on slopes having north or east exposures. On bare slopes the temperature at the two-inch level on south or west slope exposures averaged about 10 to 12 degrees Fahrenheit higher than on north or east slope exposures. A maximum range in temperature of 44 degrees during a 24-hour period was recorded on a south slope exposure at the two-inch depth level. At the six-inch level the temperature fluctuates less during a 24-hour period than at depths closer to the surface.

No excessively high temperatures were noted during the time these recordings were made. The highest spoil bank soil temperature recorded was 105 degrees on a tight, plastic glacial till and shale material in Will county.

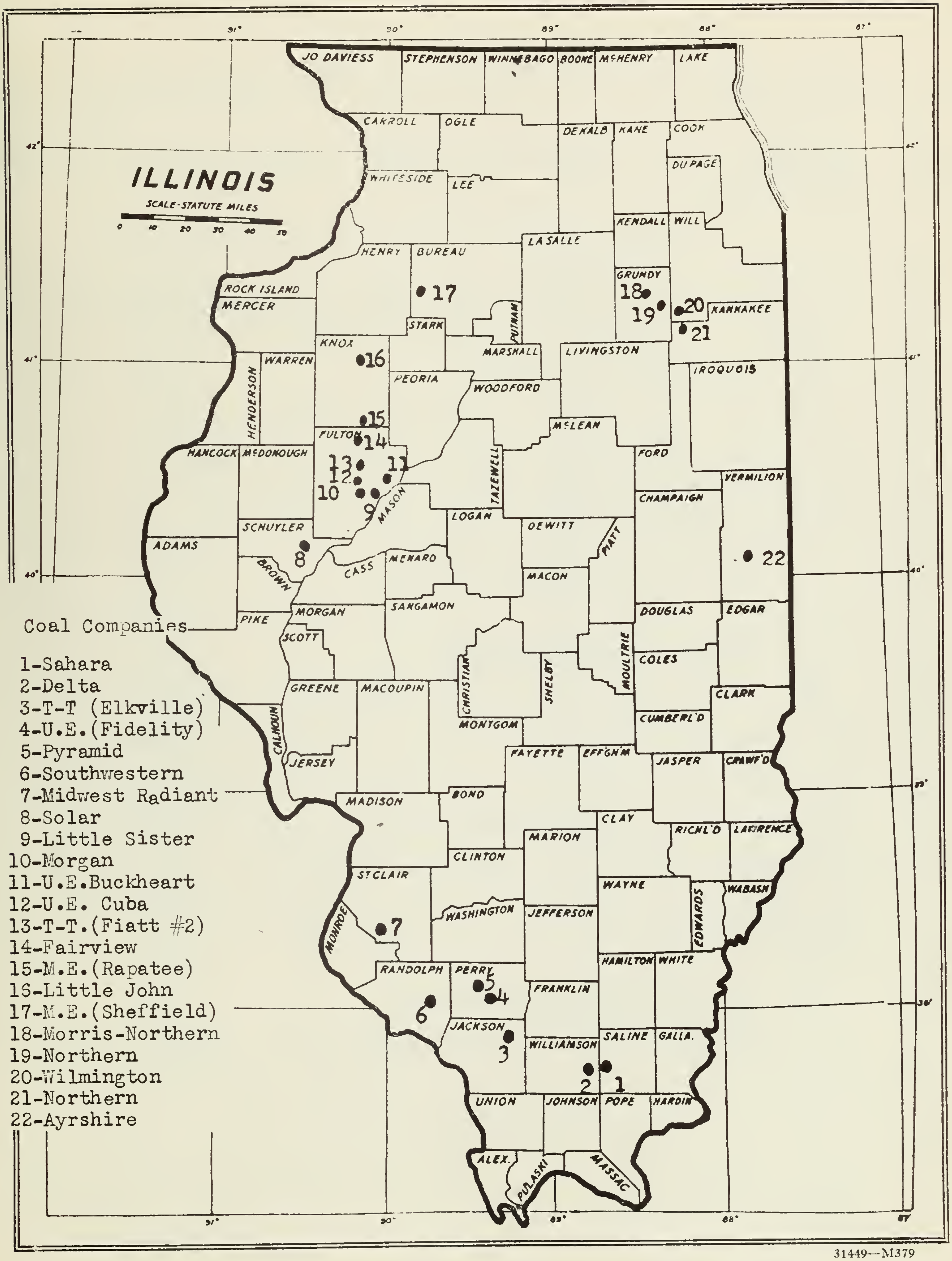
Green vegetation generally tends to equalize soil temperatures. It was found that the soil temperatures were 7 to 10 degrees lower under alfalfa cover than on bare slopes in periods of rising temperatures. Figure 3 shows vegetative growth on north and south slope exposures. Vegetation is always better on north and east exposures.

EXPERIMENTAL PLOTS.

GENERAL DESCRIPTION:

Experimental plots have been laid out at 40 different locations on 22 mine properties in 14 counties. These were established for the purpose of investigating the potentialities of revegetating and utilizing agronomic species of the spoil banks in Illinois. Figure 4 shows the

Showing vegetative growth on north and south slope exposures. The darker appearing portion to the upper right of the photograph is a sod cover on a north slope. August, 1947. (Fig. 3)



Location of Experimental Plots on Strip-Mined Coal Lands of Illinois. (Fig. 4)

location of the plots over the state. The numbers listed beside the company name are used to designate the location of the experiment. The nature of the experiments being studied is indicated by letters as the following:

A. Species adaptation alone and in association of newly mined spoils.

B. Species seeded on older banks covered with sweet clover residue, weed residue, pastures, etc.

C. Fertility treatments.

D. Establishment of a mixture of several species.

E. Forage species seeded on "strike-off" banks.

F. Forage species seed on leveled banks.

G. Rate and time of seeding.

H. Use of mulching materials.

LOCATION ON MINE PROPERTIES:

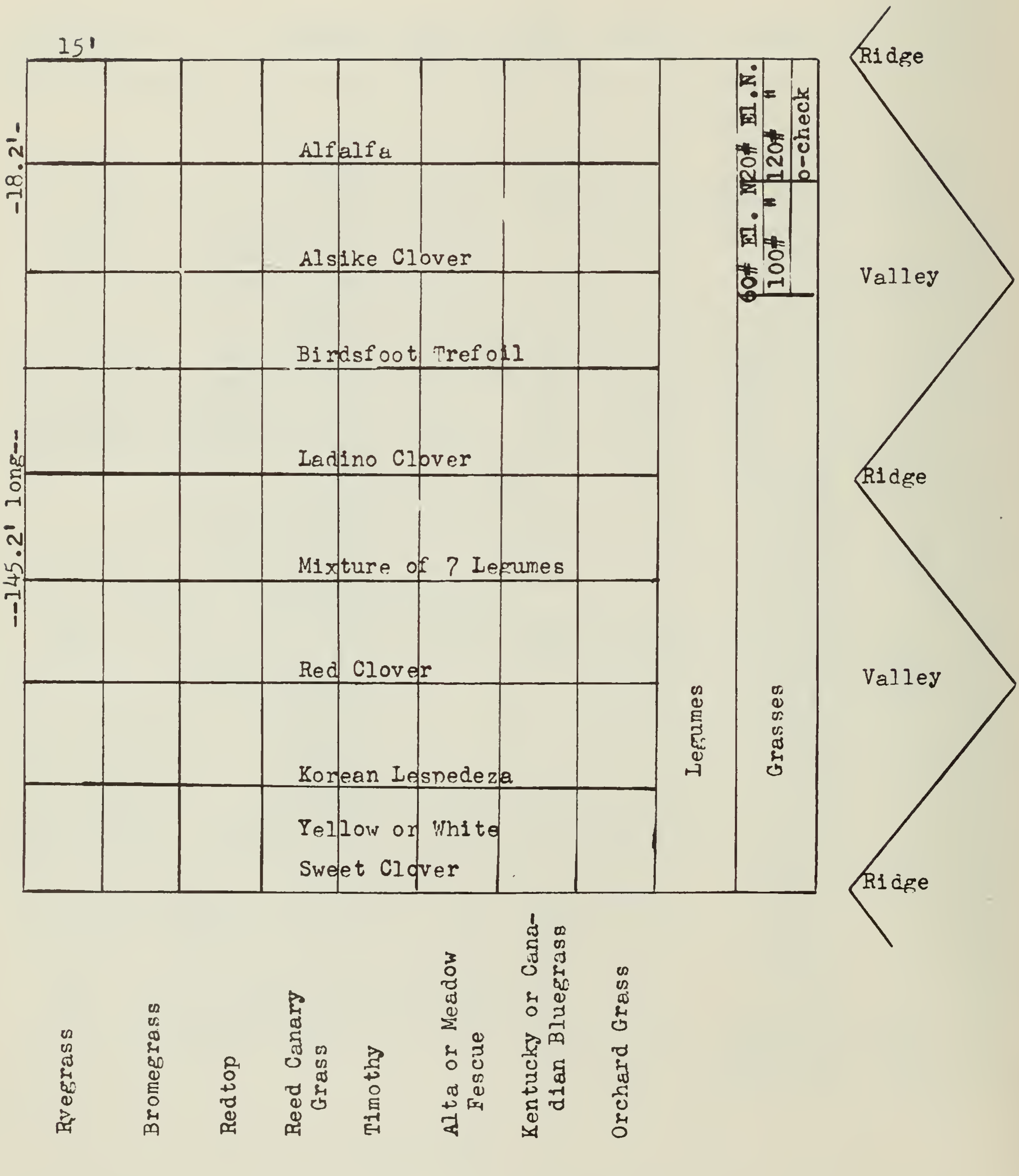
A more detailed location of the experimental plots and the total number of plots to date is listed in Table 4. In locating the plots an attempt was made to test the spoils of all member companies of the Illinois Coal Strippers Association and to test different textural soil materials making up the spoil banks throughout the state; also to test spoils formed by different stripping operations and left in various ways.

PLOT DESIGNS AND FIELD METHODS:

The plot design used in Experiments A and G to study species adaptation alone and in association on undisturbed spoil banks is shown in Figure 5-A. In the eight-by eight association plots the grasses are seeded up and down the slopes to cover two complete spoil banks wherever possible. The measurements of the plots are 145.2 feet long by 15 feet

TABLE 4. DETAILED LOCATION OF PLOTS.

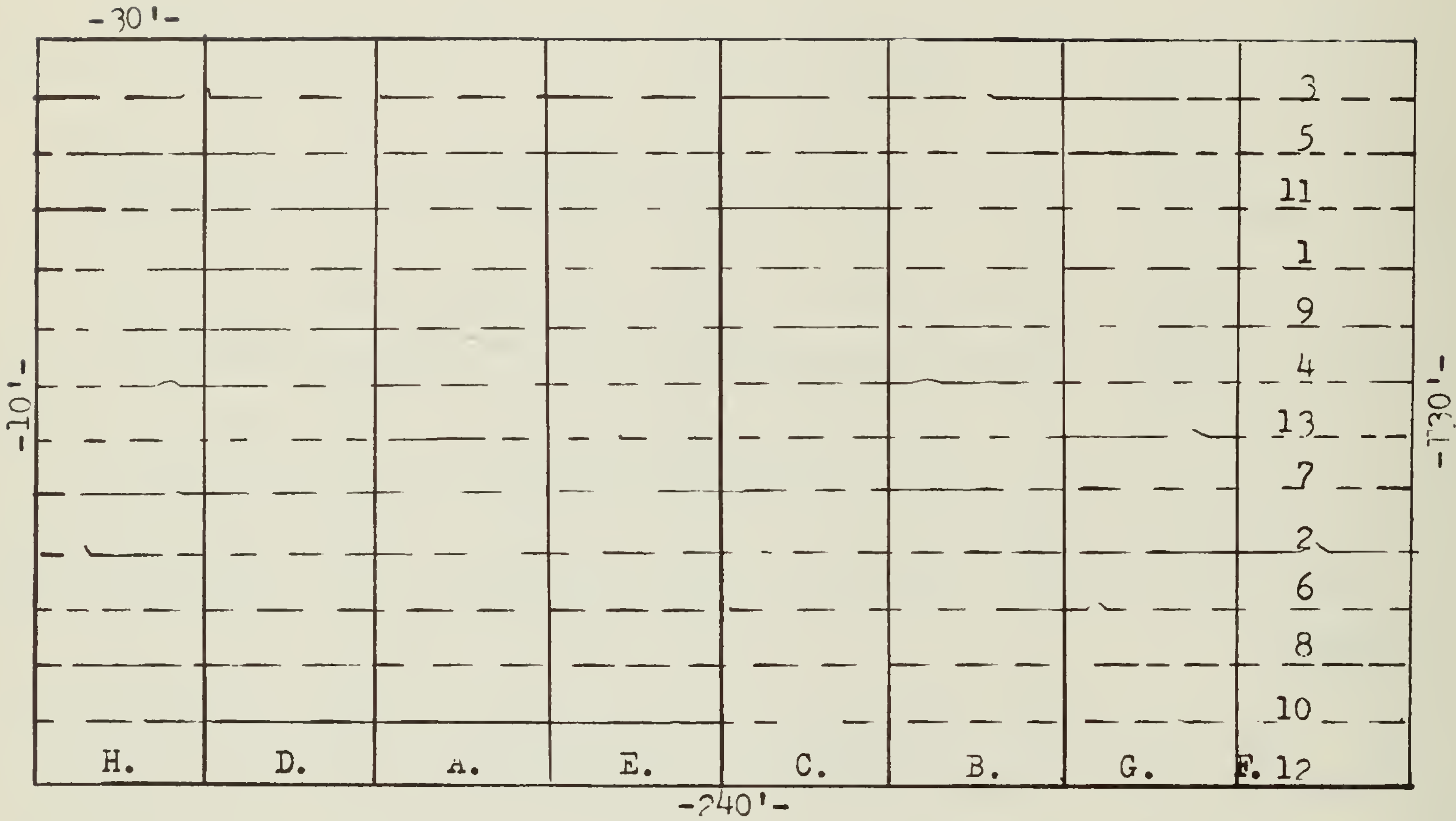
Experiment Classifi-ation.	County.	Sec-tion.	Town-ship.	Range.	Company.	Location in section.	No. of Plots.
1 - A+B	Saline	27	9 S	5 E	Sahara	NW of NW	64
1 - C	Saline		9 S	5 E	Sahara		26
2 - A+B	Williamson	22	9 S	4 E	Delta	NE of SW	68
3 - A	Jackson	7	8 S	1 W	T-T, Elkville	NW of SE	40
4 - A	Perry	15		2 W	U.E. Fidelity	SW$\frac{1}{4}$	54
4 - C	Perry				U.E. Fidelity		26
5 - A	Perry	35	5 S	3 W	Pyramid	SW$\frac{1}{4}$	54
5 - D	Perry				Pyramid		12
6 - A	Randolph	2	6 S	5 W	Southwestern	NW of SE	56
6 - B	Randolph	11	6 S	5 W	Southwestern		32
7 - A	St. Clair	35	1 N	9 W	Midwest Radiant	NW of NE	10
7 - C	St. Clair	2	1 S	9 W	Midwest Radiant	NW of NE	10
7 - A-E+F	St. Clair	2	1 S	9 W	Midwest Radiant	NW of NE	389
8 - D	Schuyler	19			Solar		23
9 - B	Fulton		6 N		Morgan		20
10 - A	Fulton	29	6 N	4 E	Little Sister		16
10 - B	Fulton				Little Sister		24
11 - A	Fulton	35	6 N	5 E	Buckheart	NE of NW	40
11 - C	Fulton				Buckheart		26
12 - A	Fulton	14	6 N	3 E	Cuba	NE$\frac{1}{4}$	30
13 - A	Fulton	2	6 N	3 E	T-T,Fiatt No.2	SE$\frac{1}{4}$	78
13 - D+G	Fulton	3			T-T,Fiatt No.2		64
14 - D+G	Fulton	3			Fairview		52
14 - E	Fulton				Fairview		12
15 - A+B	Fulton	4			Rapatee	NE of NE	60 +
15 - C	Knox				Rapatee		26
15 - F	Knox	28	9 N	3 E	Rapatee	NE of NE	113
16 - A	Knox	25	12 N	3 E	Little John	SW	16
17 - A+D	Bureau	22	16 N	6 E	M.E.Atkinson	Sheffield Mine	71 +
18 - A	Grundy				Morris		56
19 - F	Grundy	34	34	7 E	Northern Illinois	NW of SW	1
19 - A	Grundy	21	33 N	8 E	Northern Illinois	NW of SW	56
19 - B	Grundy	17	33 N	8 E	Northern Illinois	NE$\frac{1}{4}$	13
19 - C	Grundy						26
20 - A	Will	28	32 N	9 E	Wilmington	SW$\frac{1}{4}$	24
21 - A+D	Kankakee	8	39 N	9 E	Northern Illinois	SW of NE	20
21 - A-D	Kankakee	7	31 N	9 E	Northern Illinois	SW of SW	20
22 - A-D	Vermilion						None
					Total Number of Plots -		1,728



The plot design used in studying specie adaptation, alone and in association. (Fig. 5-A)

wide, making 1/20 acre in size. The legumes are seeded across the grass plots and run approximately parallel to the ridges and valleys. These plots are 18.2 feet wide by 120 feet long, making 1/20 acre plots. The species seeded are randomized and the plots are duplicated in all cases. This type of arrangement makes possible the study of 64 grass-legumes associations. All the species used are also seeded alone up and down the slope in 1/20 acre plots. Some of the grass plots were treated with various amounts of nitrogen fertilizer as shown in the grass plot of the design. The size of the treated plot is 5 feet wide by 21.5 feet long, making about 1/400 acre in size. Since the legumes were inoculated when they were seeded they were not treated with a nitrogen fertilizer.

The plot design used in Experiment C is shown in Figure 5-B. The fertilizer applications are applied up and down the slopes at the rate of 750 pounds of 8-8-8 mixed fertilizer and 100 pounds of trace minerals per acre as shown. The size of the plots are 130 feet long by 30 feet wide, making .09 acre. The 750 pounds of 8-8-8 mixed fertilizer means that 60 pounds of elemental nitrogen, 60 pounds of phosphoric acid (P_2O_5), and 60 pounds of potash (K_2O) are applied per acre. Straight materials were used and mixed in the proper amounts. When ammonium nitrate was used, 16.6 pounds of a 32.5 percent material was applied. In some cases ammonium sulfate was used and 27 pounds of a 20-percent material was applied. Twelve pounds of a 45-percent phosphate was used per plot to supply the phosphorus. Nine pounds of a 60-percent potash were required per plot to supply the necessary amounts. In all cases where trace minerals were used nine pounds of "Agro-Min" was applied per plot. This material, made by the Agricultural Minerals Company, Montgomery, Alabama, contains "zinc, copper, manganese, boron, iron, calcium,



Fertilizer Application
750 lbs./A

A	8-8-8
B	8-8-8 plus trace elements
C	8-0-0 plus trace elements
D	8-0-0
E	8-8-0
F	8-0-8
G	0-8-8
H	0-0-0

Forage Species Seeded		Pounds per plot	Rate per acre
1.	Kentucky bluegrass	1.1	15
2.	Brome	1.1	15
3.	Redtop	1.0	14
4.	Timothy	0.85	12
5.	Orchard Grass	1.1	15
6.	Alta Fescue	1.1	15
7.	Ryegrass	1.1	15
8.	Sweet Clover	1.1	15
9.	Alfalfa	1.1	15
10.	Red Clover	0.85	12
11.	Ladino	0.33	5.0
12.	Lespedeza	1.4	20
13.	Birdsfoot Trefoil	0.45	6.0

The plot design used for the fertility treatment experiment. (Fig. 5-B)

sodium, iodine, cobalt, magnesium, and ten other minor mineral elements." (Quoted from label on bags of Agro-Min.)

When limestone was needed it was supplied at the rate of 5 tons per acre in the form of hydrated lime.

Fertility plots are located on the following properties: The Sahara Coal Company, Saline County; The United Electric Coal Companies, Fidelity mine, Perry County; The United Electric Coal Companies, Buckheart mine, Fulton County; The Midland Electric Coal Corporation, Knox County; and the Northern Illinois Coal Company, Grundy County. Three of the locations were seeded and treated in the fall of 1948, and the remaining plots will be completed in the spring of 1949.

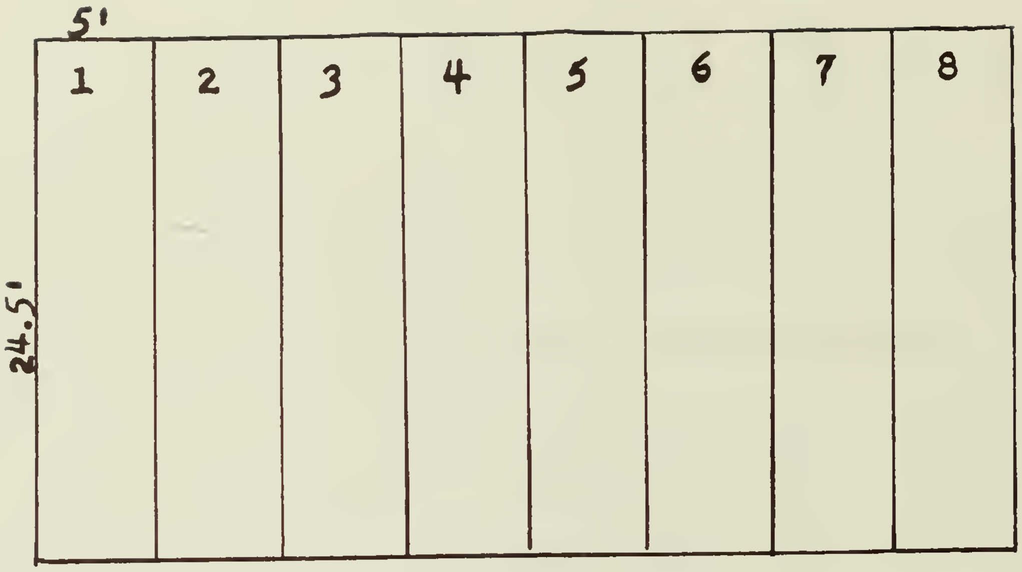
The plot design used on leveled and "strike-off" areas and for different levels of nitrogen applications on plots growing cultivated crops is given in Figure 5-C. Experiments E and F are seeded on this type of plot. The size of these plots are 1/400 and 1/200 acres. Leveled plots are located in southern Illinois on the Midwest Radiant Corporation property in St. Clair County; in western Illinois on the Midland Electric Coal Corporation, Rapatee mine, in Knox County; and in northern Illinois on Northern Illinois Coal Corporation property in Grundy county. "Strike-off" plots are located on the Midwest Corporation property and on the Fairview Collieries property in Fulton County.

Experiments B and D are seeded on essentially the same design of plots as Experiment A except that the plots are 30 feet wide instead of 15 feet.

SEEDING DATA.

ORIGIN AND VIABILITY OF SEED USED:

The forage species used, the companies from which the seed was obtained, the germination, purity and origin of the seed sown are listed



<u>Treatments.</u>

1 - No nitrogen.
2 - 20 pounds elemental nitrogen.
3 - 40 pounds elemental nitrogen.
4 - 60 pounds elemental nitrogen.
5 - 80 pounds elemental nitrogen.
6 -100 pounds elemental nitrogen.
7 -120 pounds elemental nitrogen.
8 -500 pounds 8-8-8 fertilizer.

The plot design used on leveled areas for cultivated crops with different levels of nitrogen application. Plots 1/400 acre. (Fig. 5-C)

in Appendix E. Wherever possible locally grown seed was used. Much of the seed of the native grasses was obtained from the Soil Conservation Service Nurseries at Mandan, North Dakota and Manhattan, Kansas.

TIME OF SEEDING:

The species were seeded in both the spring and the fall in all three areas, southern, western and northern Illinois. Because of the compact, plastic nature of the surface material of the spoils in northern Illinois and also because of the latitude future seedings will be made in that area only in the spring. In the fall of 1947 the seeding dates ranged from August 21 to September 24. During this period of time there appears to be little difference in results obtained. The moisture condition of the spoil banks and climate for that year were more important. In general, however, it is not recommended to seed later than about September 15 for most species.

The time of spring seedings in 1948 ranged from March 3 to April 10. In general the legumes seeded earliest made the better initial growth, but by fall there was little difference between early and late seedings.

Table 5 lists the number of plots of each of the legumes species seeded and the growth observed in both spring and fall seedings. The results of the grass plots are changing constantly. Some of the grasses are slow to germinate, and because of the lack of nitrogen in spoil bank soils are slower to become established. Therefore a summary table for the grasses is not included at this time. A total of 136 plots on three locations was destroyed during 1948 as a result of mining operations and much valuable information was lost.

In most cases, on fresh spoils especially, legumes did better

TABLE 5. SURVIVAL OF LEGUMES SEEDED ON PLOTS IN THE FALL AND SPRING AS OF SEPTEMBER, 1948.

Specie.	Number of Plots Total.	Fall seeded plots. Good	Fall seeded plots. Poor-None	Spring seeded plots. Good	Spring seeded plots. Poor-None.	Notes.
Alfalfa	34	4	8	20	2	Best.
Alsike	29	2	6	15	6	Comes in naturally on many banks especially in valleys.
Birdsfoot trefoil	35	-	8	14	7	Good promise, spring seed only.
Korean lespedeza	33	-	12	15	6	OK on fresh spoils in spring.
Ladino	35	-	14	9	12	Good in valleys generally, spring seed only.
Mix legumes	25	4	4	15	2	Good overall.
Red clover	33	4	6	13	7	
Sweet clover	33	2	10	13	8	Root rot, pea aphid & sweet clover weevil hurt young sweet clover in 1948.
Hubam	17	-	-	8	9	
Spanish Sweet clover	8	-	-	4	4	
Kobe lespedeza	10	-	-	9	1	
Sericea lespedeza	12	-	2	4	6	
Common lespedeza	4	-	-	2	2	
Mammoth clover	14	2	-	9	3	Good.
Crimson	14	3	3	2	6	
Subterraean	14	-	6	-	8	
White Dutch	12	-	2	7	3	
Hop	14	-	6	-	8	Very little seen.
Bur	7	-	-	-	7	None.
Alyce	15	-	-	-	15	None.
Austrian winter pea	9	-	4	-	5	
Big broadleaf trefoil	20	-	-	10	10	Birdsfoot trefoil better.
Yellow trefoil	18	3	1	10	4	Good in south.
Persian clover	5	-	-	-	5	
Lupines	9	-	-	-	9	None
Lappacea	15	-	-	2	13	
Sanfoin	13	-	-	0	13	Few plants seen. Perhaps an inoculation problem.
Crown vetch	5	-	-	0	5	Old seed.
Butter clover	12	5	0	3	4	Shows promise.
Early Korean lespedeza	7	-	-	6	1	Use in more northern latitudes.
Kudzu	5	-	-	-	5	1947, 500 plants poorstock.
Kudzu	4	-	-	4	-	1948, 200 plants - good.

when seeded in the spring. Alfalfa, yellow trefoil, mammoth, medium red clover, and button clover, an annual alfalfa, gave fair to satisfactory stands when seeded in the fall. Grasses seeded in the fall in southern and western Illinois on some plots were better than when seeded in the spring. Kentucky bluegrass, the tall fescues, orchard grass, and red-top did well when seeded in the fall on fresh spoils. From results obtained to date it appears to be advisable to seed grasses with the legumes in a mixture instead of seeding legumes alone first and then trying to introduce grasses into the stand at a later date.

RATE OF SEEDING AND CONDITION OF SPOIL BANKS:

Seedling counts were made on a number of species at several locations. A one-foot square was used. The counts again indicate that less than one-half of the seed that was seeded germinated and established itself on the slopes. Much of the seed was washed down into the valleys where heavy stands were generally noted. This is especially true of the larger seeded-species.

Thus it seems evident that a heavier seeding should be used than that normally recommended in farming practices; also, there is probably an ideal time to seed the species to result in a minimum washing away of the seed. When possible the seeding after a rain when the banks are moist and more receptive to the seed is recommended. Heavy rains immediately following the seeding cause washing which reduces the stands.

Better stands and ground cover are usually obtained on north than on south slope exposures. It was also noted that the top two or three feet of the peaks were not well covered. Striking-off to a width of 12 to 16 feet will do much to improve the stand of forage since the tops will be flattened and the length of the slope, usually subject to severe erosions will generally be shortened. Also the tops thus prepared have

made good seedbeds. Figure 6 shows an area treated in this way before seeding.

Ground cover studies on an established spoil bank pasture taken in the fall of 1948 show about 91 percent ground cover on the strike-off tops, compared to 64 percent ground cover on untreated tops. The percentage of weeds was 6 percent higher on the untreated than on the strike-off tops.

Various rates of application of seed of species seeded alone and in mixtures are being studied. Tyner (4) suggested that the seeding rates commonly used should be increased by 30 percent. An excellent stand was obtained in southern Illinois by seeding a mixture of legumes at the rate of 17 pounds per acre. At this time it is recommended that at least a minimum of 15 pounds of mixture should be seeded depending on the species used. Experiments on this problem are still being carried on.

Grass species and grass-legume mixtures have been seeded into a pre-established stand of sweet clover, weeds, etc. (Experiment B.) In most of the cases the areas have not been grazed. Satisfactory stands of sweet clover and weeds have not been established by seeding into such areas. Generally the stands of sweet clover and weeds have been so rank that other species cannot compete with the established growth. Plots seeded on such areas that are pastured are still being studied. Thus it seems better to seed grasses along with the legumes in a mixture on fresh spoils than to wait and attempt to get the grasses started later in most locations. Far better stands are established on fresh spoils than on older spoils. If pasture establishment is to be the land use of the stripped land, the fresh, bare spoil banks should be seeded every year as rapidly as stripped up to the actual shovel operation.

Spoil bank ridges struck-off to a width of 12-16' by means of a bull-dozer. Fairview Collieries Corporation, Fulton County. (Fig. 6)

GROWTH AND PROGRESS OF THE SPECIES:

The forage species seeded on the spoil banks were listed in the first annual report and the legumes used are listed in Table 5. As is shown in the table and was known previously, species such as the lespedezas, sweet clovers, birdsfoot trefoil, and ladino should be seeded only in the spring. The legumes showing up best are alfalfa, sweet clover, lespedeza, yellow trefoil, birdsfoot trefoil, medium and mammoth red clover, and alsike clover. Ladino, button clover and Kudzu have given very good stands under some conditions. Legumes, even though inoculated are not always well nodulated. Yellow and unthrifty appearing legume plants may be due to this fact.

Of the grasses orchard grass, ryegrass, the fescues (meadow, Alta and Kentucky 31), redtop, timothy, Kentucky and Canada bluegrass, and bromegrass have been most successful. Orchard grass has given the best results to date. Ryegrass starts extremely fast but lacks persistence so that by the second year very little is left. Rhodes grass seeded in only three of four locations has shown interesting growth. More plots of this grass will be seeded in 1949. Figures 7 to 12 give a pictorial record of forage growth obtained on spoil banks.

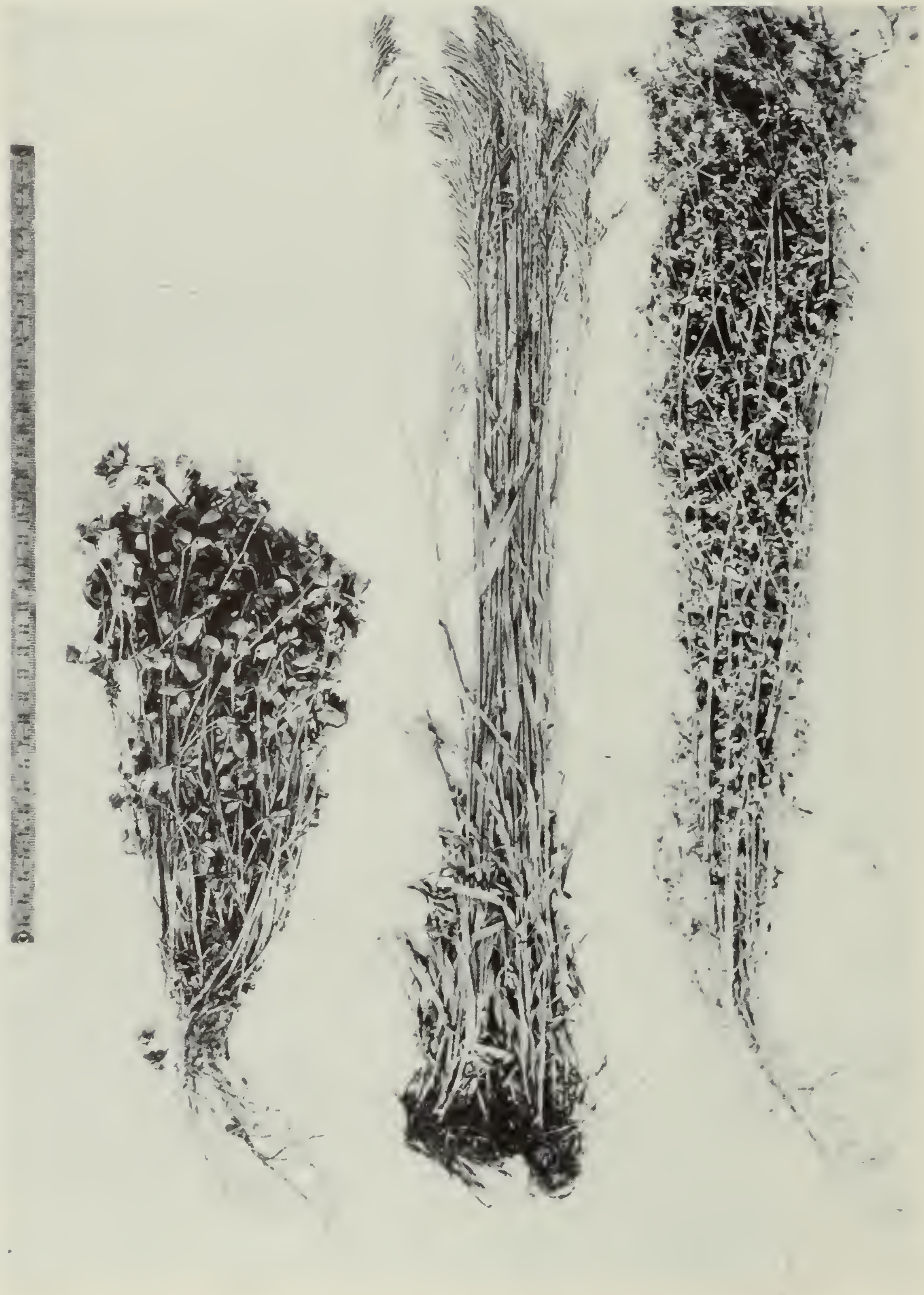
MIXTURE SEEDINGS:

Better pastures usually result when a mixture of different grasses and legumes is seeded than when a specie is seeded alone. There are a number of reasons for using mixtures. They give more complete coverage and better control of erosion as the foliage protects the soil and the roots hold it. More forage is produced and the pastures are likely to be productive over a longer period as the legumes furnish nitrogen for the grasses and these in turn lessen winter killing of the legumes. Cattle and sheep are less apt to bloat on mixtures of grasses and legumes than

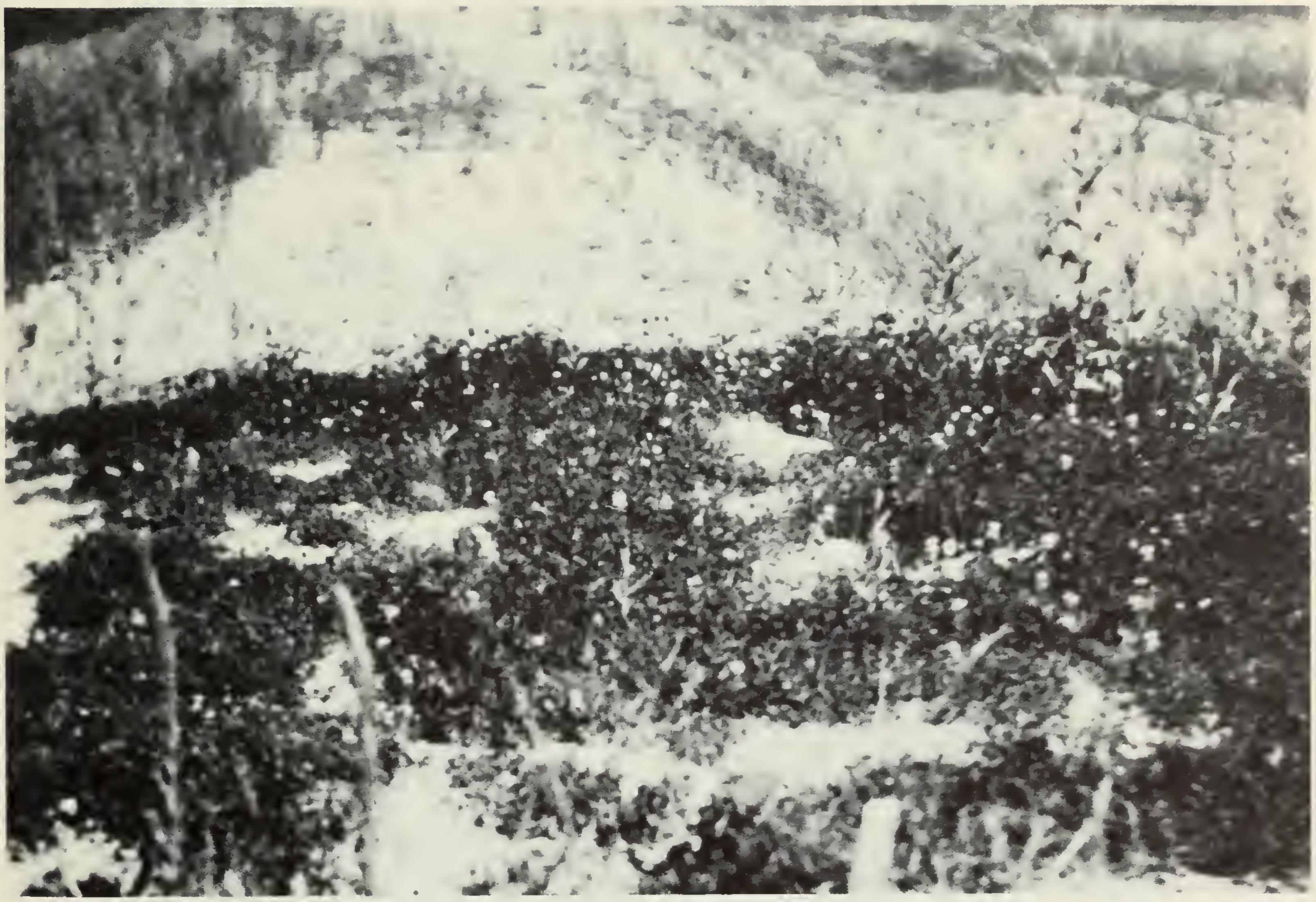
Sweet clover in full bloom on spoil banks. Northern Illinois Coal Corporation, Grundy county. July, 1948. (Fig. 7)

Red clover growing on spoil banks in St. Clair county,
Midwest Radiant Corporation. 1948. (Fig. 8)

Mixture of ryegrass, alfalfa, sweet clover, alsike mammoth clover, and birdsfoot trefoil seeded on spoil banks. Little John Coal Company, Knox County, 1949. (Fig. 9)



Individual red clover, bromegrass, and alfalfa plants that were growing on spoil banks. Truax-Traer Coal Company, Fulton County, 1948. (Fig. 10)



Ladino growing on a strike-off area plot. Midwest Radiant Corporation, St. Clair County, 1947. (Fig. 11)

Kudzu in foreground showing good ground cover. United Electric Coal Companies, Fidelity mine. Perry County, 1948. (Fig. 12)

on legumes alone. Mixed pastures afford a variety of grazing and help provide a well balanced ration.

Mixtures that have been successful when seeded on fresh spoils in the spring include:

		Lbs.		Lbs.	Total per acre. Lbs.
(1)	Ryegrass	5	Mammoth clover	1.5	
	Alfalfa	2	Alsike clover	1	
	Sweet clover	2.5	Birdsfoot trefoil	1	
					13
(2)	Alfalfa	4	Lespedeza, K.	5	
	Sweet clover	5	Ladino	1	
					15
(3)	Sweet clover	3	Brome	4	
	Alfalfa	3	Orchard grass	3	
	Lespedeza	4	Redtop	2	
					19

A mixture recommended for early fall seeding is:

Alfalfa	5	Orchard grass	3	
Mammoth clover	3	Redtop	2	
Alsike	2	Timothy	2	
				17

Sweet clover is the only specie of which forage yields were taken in 1948. Dry matter yields taken from three areas in western Illinois averaged 2.01 ton per acre. In connection with the pasturing projects, yields from an established spoil bank pasture in western Illinois were 1.39 tons per acre and from a less well established area in southern Illinois of which a large percentage was sweet clover was 1.17 tons of dry matter per acre.

As noted in Table 5 sweet clover seeded in the spring failed on about one-half of the plots. Sweet clover weevil and pea aphid killed much of the young growth in 1948. Root rot, *Phytophtora cactorum*, killed or severely damaged second year sweet clover stands in many areas. Yellow blossomed varieties seemed harder hit than the white blossomed vari-

ety. It is doubtful if the clover in such areas has reseeded itself.

RESULTS OF EXPERIMENTS WITH CULTIVATED CROPS:

The following cultivated crops were sown on leveled areas in St. Clair and Grundy counties; wheat, rye, oats, corn, and soybeans for grain production, and sweet sudan--soybean for hay. The plot design is shown in Figure 5-C. The results obtained with rye seeded on leveled and strike-off areas in St. Clair county are listed in Table 6-A. Wheat yields obtained were very similar to those obtained with rye. The data indicates what may be expected if adequate amounts of nitrogen only are added. Rye growing on a leveled area is shown in Figure 13.

Yields of soybean-sweet sudan hay are listed in Table 6-B. The increase in yield was due primarily to the heavier growth of sweet sudan where higher applications of nitrogen were made. Soybeans, even though they were inoculated, did not contribute much to the total weight. Growth of this mixture is shown in Figure 14.

Soybeans that were seeded alone did not thrive any better than those seeded in the sweet sudan. No difference due to treatment was noted. Plant growth was small, approximately 12 to 18 inches in height, and very few pods were set.

Corn was also planted on treated plots. The plots were 43 feet long by six feet wide, with 16 hills per row and 2 rows per plot. Six different treatments were applied as follows: (1) 50 pounds of elemental nitrogen per acre was hill-dropped; (2) 50 pounds elemental nitrogen per acre hill-dropped at planting time plus 70 pounds per acre side-dressed when the corn was about knee high; (3) 100 pounds of elemental nitrogen plus 100 pounds of potash (60%) was broadcast ahead of planting; (4) 100 pounds of potash hill-dropped per acre; (5) corn planted with inoculated Kingwa soybeans; (6) no treatment.

TABLE 6-A. RYE YIELDS ON LEVELED AND STRIKE-OFF PLOTS ON MIDWEST RADIANT CORPORATION PROPERTY IN ST. CLAIR COUNTY.

Treatment lbs. elemental nitrogen.	Number of plots leveled	strike-off.	Yields Leveled bu/A	Strike-off bu/A	Test Weight average.
0	2	1	5.3	5.8	53
20	2	1	10.0	12.4	53
40	2	1	13.6	17.8	52
60	2	1	24.8	18.2	52
80	2	1	22.9	10.4	52
100	2	1	26.0	28.1	51
120	2	1	30.2	....	52.5
500 lb.8-8-8	2	1	13.2	13.6	53

TABLE 6-B. SWEET SUDAN-SOYBEAN HAY YIELDS ON LEVELED PLOTS.

Treatment lbs. elemental nitrogen.	Number of Plots.	Yield tons/A.	Chemical analysis.
0	2	0.413	
20	2	2.112	
40	2	2.358	
60	2	3.096	
80	2	3.204	
100	2	3.804	
120	2	6.818	
500 lb. 8-8-8	2	1.428	

Rye growing on a leveled area. Midwest Radiant Corporation. St. Clair County, 1948. (Fig. 13)

Sweet sudan - soybean mixture growing on a leveled area. Midwest Radiant Corporation, St. Clair County, 1948. (Fig. 14)

The yields obtained on the corn plots were as follows:

Plot Number.	Treatment.	Yield bushels per acre.
1	50 lbs. nitrogen per acre hill-dropped.	17.1
2	50 lbs. nitrogen per acre hill-dropped plus 70 lbs. per acre side-dressed when corn about 18 inches high.	60.5
3	100 lbs. nitrogen and 100 lbs. potash per acre, broadcast.	42.3
4	100 lbs. potash, hill-dropped.	0
5	Inoculated soybeans planted in the hill with the corn.	0
6	No treatment.	0

Figure 15 shows the corn on plots (3) and (4).

Wheat and rye seeded on similar plots in Grundy county died out in the spring even though fair growth was obtained in the fall. The texture of the soil is high in clay and does not have as good drainage as that in St. Clair County.

These plots of cultivated crops would indicate that where areas are free of rock and where the soil material is silty in texture, applications of nitrogen result in good growth.

ANIMAL GAINS AS A METHOD OF MEASURING YIELDS AND QUALITY OF SPOIL BANK FORAGE.

PASTURING PHASE:

In an effort to determine the value of a strip-mined land for agricultural production, a project in which beef cattle grazed on spoil bank pastures was initiated in 1948. The grazing tests were carried out on lands in Fulton county owned by Mr. Byron Somers and on lands in Perry county owned by the United Electric Coal Companies, Fidelity mine.

Growth of corn on treated and untreated plots on a leveled area. Midwest Radiant Corporation, St. Clair County, 1948. (Fig. 15)

Twenty yearling steers of medium grade were used in each of the two areas. Ten steers were grazed on spoil bank pastures, while the same number were run on ordinary farm pastures as a check, or control group. The control pasture used in Fulton County was an 80-acre bluegrass pasture within a mile of the area grazed by the test group. Ten steers on 80 acres insured adequate forage the whole season. As no suitable established pasture could be secured in Perry County for the test, the control group was grazed at the Dixon Springs Experiment Station which is located in Pope County about 75 miles southeast of the Perry County strip-mined land.

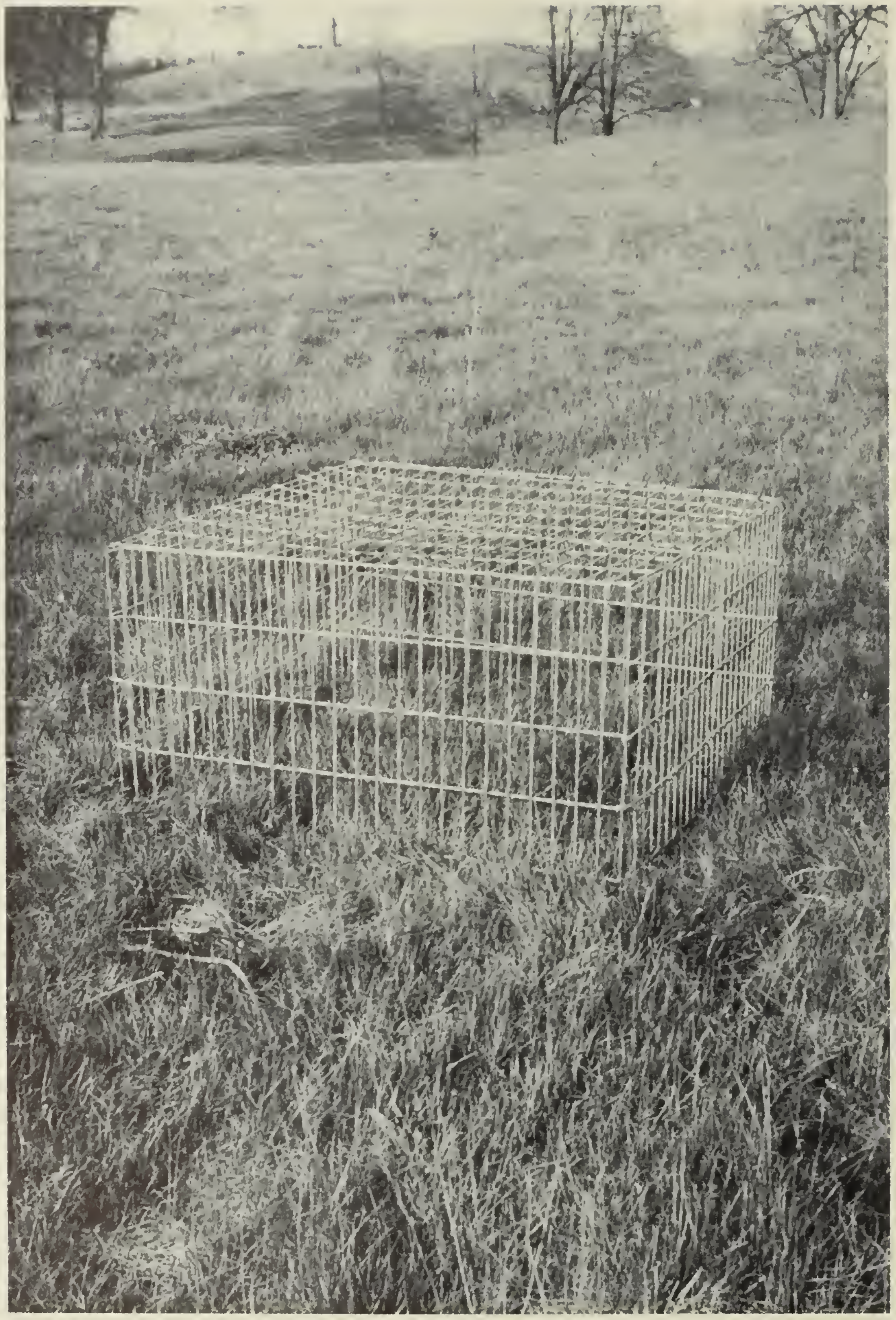
The spoils pasture in Fulton county on which the test was made was mined about 12 years ago. Sweet clover was seeded in 1938. Grasses and other legumes were seeded later. A good stand of grasses and legumes has been secured over a considerable portion of the area.

A survey of the botanical composition of the pastures was made in the spring and again in the fall. On April 29, 1948, measurements were made by using a quadrate and estimating the percentage of growing cover contributed by each specie in each quadrate. On October 7, 1948, the ground cover was obtained by means of the point quadrate method. Bluegrass and sweet clover were the dominant species in the spoil bank pasture. Table 7 shows the percent each specie is contributing to the pasture sward and the percent of bare area.

Yields were taken by using four foot square metal cages in each pasture which protected the sample areas from grazing. The cages were placed in locations representative of the general area. On the spoil banks pasture the yield thus computed was found to be 1.4 tons of oven-dry forage per acre. The yield of the bluegrass pasture was computed to be 1.0 ton per acre. Figure 16 shows the cage used to get the yield

TABLE 7. PERCENT EACH SPECIE IS CONTRIBUTING TO THE TOTAL COVER AND THE PERCENT OF BARE AREA OF THE SPOIL BANK PASTURE AND THE UNDISTURBED BLUEGRASS PASTURE, 1948.

Specie.	Spoil bank pasture		Undisturbed Bluegrass pasture April 29, 1948, Spring percent of total.
	April 29, 1948 Spring percent of total.	October 7, 1948 Fall percent of total.	
Grasses:			
Bluegrass	36	41.0	63
Redtop	7	7.0	1
Timothy	7	3.0	3
Bromegrass	9	10.0	..
Wild grasses	2	5.0	6
Legumes:			
Alfalfa	1	0.5	..
Sweet clover	11	18.0	..
Red clover	6	2.0	1
Alsike clover	4	7.0	..
White clover	1	0.5	5
Lespedeza	Trace	....	Trace
Weeds	8	6 (100%)	10
Dead or no vegetation	8 (100%)	6	11 (100%)



Four-foot square metal cage used to protect an area from grazing and under which forage was cut to determine forage yields of pastures; Lot 2 bluegrass pasture in Fulton County, 1948. (Fig. 16)

data.

The Perry county area has been stripped more recently and the pasture is not as well established. The area was seeded in the spring of 1947. The following species were observed growing: sweet clover, alfalfa, red clover, lespedeza, orchard grass, ryegrass, redtop, alta fescue, timothy, and Kentucky bluegrass. During the first part of the grazing season the forage was primarily sweet clover. During the latter part of the season, the orchard grass came along very fast and formed a good part of the forage ration. Yields of oven-dry forage taken in Perry county by the same method as described for Western Illinois were computed to be 1.2 tons per acre. A large part of the forage weights resulted from the good sweet clover growth in the early spring.

The pasture at the Dixon Springs Experiment Station was a grass-legume mixture on improved land.

The results obtained in terms of animal gains during the pasture season, a total of 163 days, were as follows:

	Av. Wt. April 22 1/ lbs.	Av. Wt. Oct. 2 1/ lbs.	Av. Total Gain 1/ lbs.	Av. Daily Gain 1/ lbs.
FULTON COUNTY TEST				
Test Steers, Spoils Pasture	669	863	194	1.19
Control Steers, Grass-legume Pasture	659	870	211	1.29
PERRY COUNTY TEST				
Test Steers, Spoils Pasture 2/	717	890	173	1.06
Control Steers, Grass-legume Pasture	665	865	200	1.23

1/ Weights at Urbana April 22 before the cattle were trucked to their respective pastures and at Urbana on October 2, the day following their return. Obviously the cattle suffered considerable shrinkage on both trips.

2/ Average initial and final weights on only three steers returned to Urbana.

In analyzing the individual gains, it was found that for the

Lot 1 steers on spoil bank pasture in Fulton county, the total gains varied from 280 pounds to 130 pounds for the 163 pasture day period. The average total gain was 194 pounds and the average daily gain was 1.19 pounds. For the Lot 2 steers on bluegrass pasture in Fulton County, the range in total gains was the same as Lot 1 while the average total gains were 211 pounds and the average daily gains were 1.29 pounds. Figure 17 shows the nature of the spoil bank pasture in Fulton county. Figure 18 shows the Lot 2 cattle on the bluegrass pasture.

The average weights listed for the Lot 3 steers on the Perry County spoil bank pasture are for three steers only. It was impossible to get the rest of the steers from the spoil bank pasture at the time the truck picked up the steers on the grass-legume pasture at the Dixon Springs Experiment Station to truck them back to Urbana for the feet-lot phase. See Table 8 for individual data on all steers.

FEED LOT PHASE:

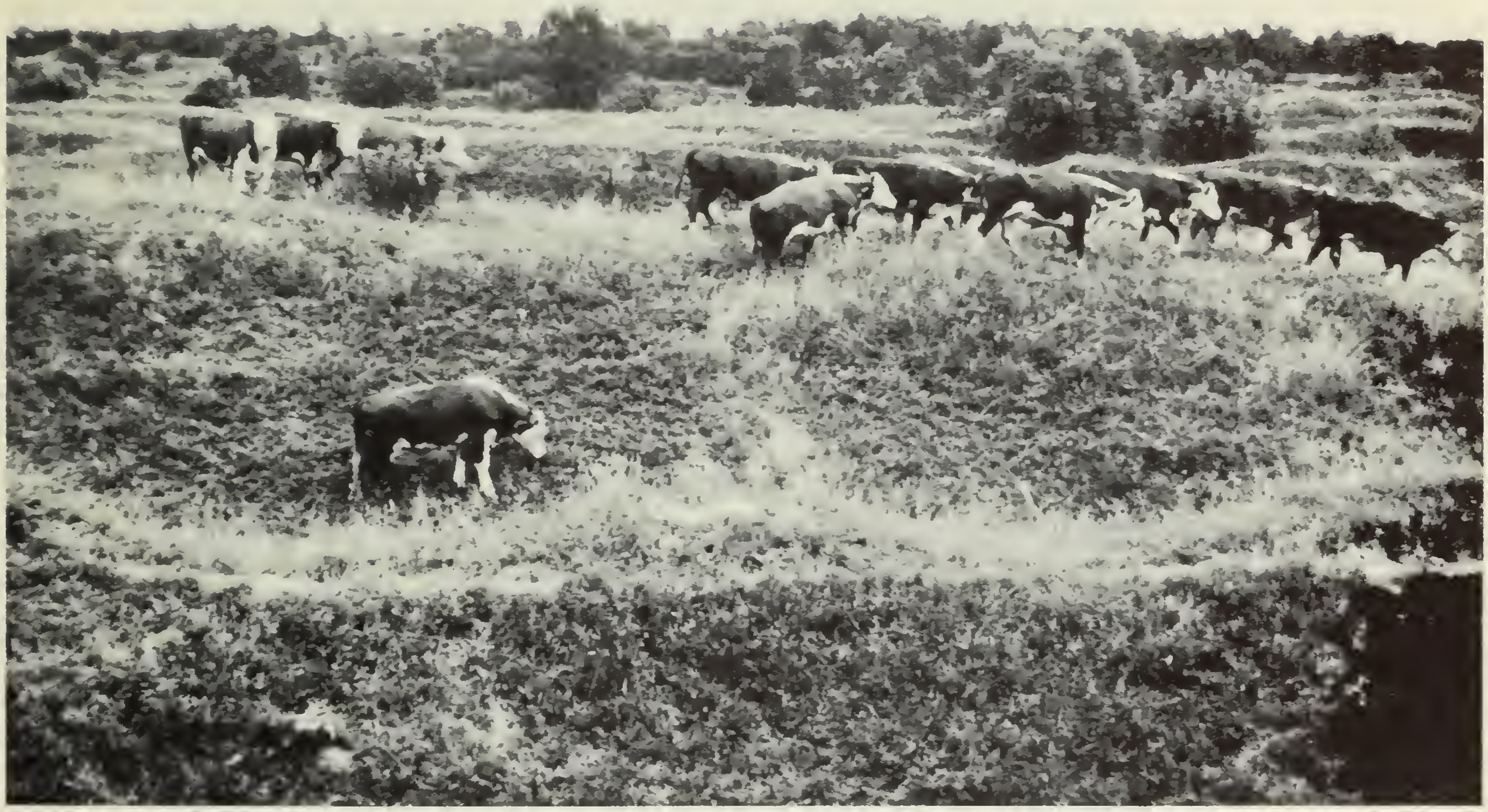
The steers were in the feed lot a total of 45 days, during which time they were fed broken ear corn and clover hay. Here again there was wide variation in the total gains made by individual animals. See Table 8. The average daily gains in the drylot were: Lot 1 - 1.98 pounds; Lot 2 - 2.18 pounds; Lot 3 - 2.07 pounds; and Lot 4 - 2.09 pounds. Figures 19 and 20 show the steers after being in the drylot for approximately 20 days.

A summary of the gains made in the feed lot and the market grades and dressing percentages is given in Table 9.

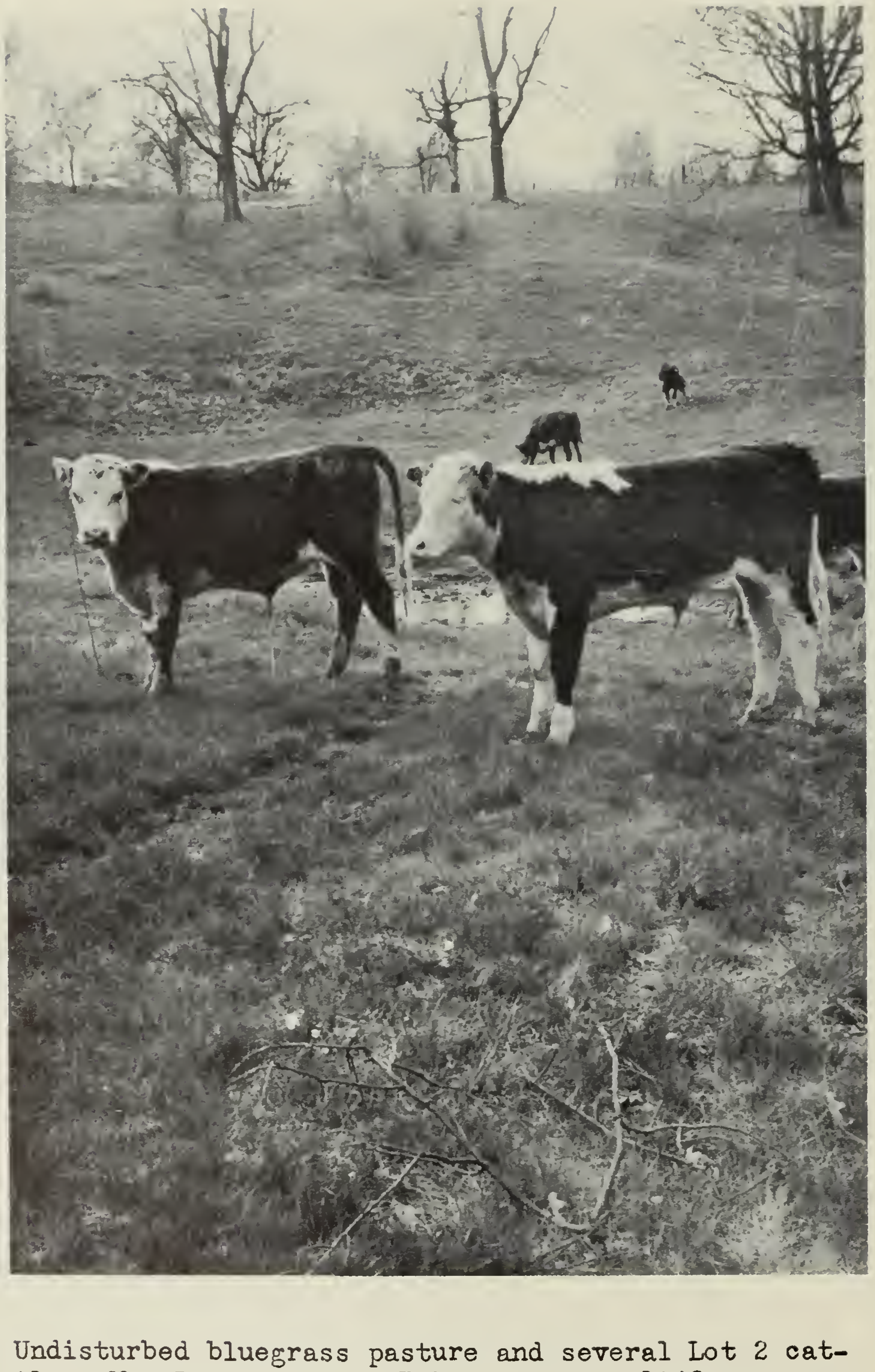
CHEMICAL COMPOSITION OF FORAGE PLANTS.

SPOIL BANK FORAGE:

The species that became established were sampled at various times during the year in order to determine the chemical composition of forage plants grown on the spoil banks. Approximately 350 such samples have been collected and prepared and are being analyzed.



Showing cattle and spoil bank pasture on which Lot 1 cattle grazed. Mr. Byron Somers, Fulton County, 1948. (Fig. 17)



Undisturbed bluegrass pasture and several Lot 2 cattle. Mr. Byron Somers, Fulton County, 1948.
(Fig. 18)

TABLE 8. DATA GIVING INDIVIDUAL WEIGHTS AND GRADES OF STEERS PASTURED AND FED IN 1948.

A. Lot 1 -- Established Spoil Bank Pastures in Fulton County.

Tattoo	Pasture weights. On	Pasture weights. Off	Gain on pasture.	Weight off drylot.	Gain in drylot.	Total gain.	Wt. of warm carcass.	Grade by U.of I.	Grade by Fed'l. Gov't.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		
161	690	910	220	1040	130	350	618	B-	B-
65	700	870	170	1000	130	300	581	B-	B
69	660	870	210	930	60	270	551	B-	B-
73	610	750	140	860	110	250	496	B-	C+
77*	650	840	190	770	-70	120	426	C+	C
81	680	960	280	940	-20	260	534	B+	B+
85	630	850	220	950	100	320	532	B	B
89	770	920	150	1050	130	280	552	B-	C+
93	660	790	130	960	170	300	553	B+	B+
97	640	870	230	1020	150	380	534	B-	B
Averages	669.0	863.0	194.0	952.0	106.7*	283.0			

B. Lot 2 -- Undisturbed Bluegrass Pasture in Fulton County.

Tattoo	Pasture weights. On	Pasture weights. Off	Gain on pasture.	Weight off drylot.	Gain in drylot.	Total gain.	Wt. of warm carcass.	Grade by U.of I.	Grade by Fed'l. Gov't.
131	640	910	270	1030	120	390	590	B-	B-
66	640	920	280	1020	100	380	520	B-	C+
70	670	800	130	830	30	160	488	B-	B
74	700	920	220	1030	110	330	570	B-	C+
78	620	780	160	940	160	320	505	B-	B
82	660	900	240	980	80	320	536	B-	C+
86	700	910	210	1000	90	300	560	B	B-
90	680	870	190	990	120	310	561	B-	B-
94	610	770	160	840	70	230	481	B-	C+
98	670	920	250	1020	100	350	566	B-	B-
Averages	659.0	870.0	211.0	968.0	98.0	309.0			

C. Lot 3 -- Spoil Bank Pastures in Perry County.

Tattoo	Pasture weights. On	Pasture weights. Off	Gain on pasture.	Weight off drylot.	Gain in drylot.	Total gain.	Wt. of warm carcass.	Grade by U.of I.	Grade by Fed'l. Gov't.
149	600								
67	680	850	170	990	140	310		No carcass	
71	700								
75	710	870	150	890	20	170		information	
79	680								
83	630							obtained.	
87	760	950	190	1070	120	310			
91	740								
95	670								
Averages	675.0	890.0	170.0	983.0	93.0	263.0			

(Continued)

TABLE 8. -- (continued)

D. Lot 4 -- Grass-Legume Pasture at Dixon Springs Experiment Station.

Tattoo	Pasture weights. On	Pasture weights. Off	Gain on pasture.	Weight off drylot.	Gain in drylot.	Total gain.	Wt. of warm carcass.	Grade by U. of I.	Grade by Fed'l. Gov't.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		
101	660	910	250	1000	90	340			
68	740	890	150	940	50	200			
72	620	820	200	920	100	300	No carcass		
76	630	760	130	790	30	160			
80	650	920	270	1040	120	390	information		
84	710	900	190	1020	120	310			
88	630	820	190	870	50	240	obtained.		
92	660	800	200	990	130	330			
96	620	860	240	1030	170	410			
100	730	940	180	990	80	260			
Averages	665.0	865.0	200.0	959.0	94.0	294.0			

* This steer was sick, therefore, 9 steers were used in computing the average gains in drylot.

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Lot 1 steers in the drylot. These steers were grazed on an established spoil bank pasture in Fulton County, 1948. (Fig. 19)

Lot 2 steers in drylot. These steers were grazed on an undisturbed blue-grass pasture in Fulton County, 1948. (Fig. 20)

TABLE 9. FATTENING IN DRY LOT AFTER REMOVAL FROM PASTURE.

	Lot 1.	Lot 2.	Lot 3.	Lot 4.
Number of steers ------------------	10	10	3*	10
Average weight into feed lot, October 2, pounds --------------	863	870	890	865
Average weight off feed lot, November 16, pounds ------------	952	968	983	959
Average gain per head, pounds -----	89	98	93	94
Average daily gain in dry lot, pounds ------------------------	1.98	2.18	2.07	2.09
Average gain per head on pasture 163 days, pounds ---------------	194	211	173	200
Average gain in dry lot, 45 days, pounds ------------------------	89	98	93	94
Average total gain, pounds --------	283	309	263	294
Average daily ration				
broken ear corn, pounds --------	17.1	17.1	18.7	16.1
clover hay, pounds ------------	6.0	6.0	5.9	6.0
Selling price Chicago, November 17, 1948 (purchased by Swift & Co.)	21.50	22.00	23.15	24.25
Dressing percentage (Swift's)	56.8	56.0	Not obtained.	
Carcass grades				
Mr. Johnson - University of Illinois. ------------------------	2 B+ 1 B 6 B- 1 C+	1 B 9 B	No carcass information obtained.	
Government Grader ----------------	2 B+ 3 B 2 B- 2 C+ 1 C	2 B 4 B- 4 C+		

* Average, initial and final weights on only three steers returned to Urbana.

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This section of the report will be submitted later when some of the results of the chemical analysis of spoil bank forage are completed. Table 10 gives the chemical composition of hay and forage crops grown on farm land over a period of years. (3)

DISSEMINATION OF INFORMATION.

An inspection tour of spoil bank reclamation work in Indiana and Illinois was conducted jointly by the Purdue Agricultural Experiment Station and the Illinois Agricultural Experiment Station, cooperating with the Illinois Coal Strippers Association on June 16-19 inclusive. June 18 and 19 were spent touring southern and western Illinois areas.

Those attending the Illinois tour wholly or in part were:

Dean C. R. Orton, Director, W. Virginia Exp. Sta., Morgantown, W. Va.
S. L. Galpin, Hydrologist, W. Virginia Exp. Sta., Morgantown, W. Va.
E. H. Tyner, Assoc. Agronomist, W. Virginia Exp. Sta., Morgantown, W. Va.
H. A. Wilson, Assoc. Bacteriologist, W. Va. Exp. Sta., Morgantown, W. Va.
A. Alexander, Chief, State Dept. of Mines, Charleston, W. Va.
W. Moore, Inspector, State Dept. of Mines, Charleston, W. Va.
J. Hall, Inspector, State Dept. of Mines, Charleston, W. Va.
A. G. Chapman, Forester, Central States Forest Exp. Sta., Columbus, O.
G. A. Limstrom, Forester, Central States Forest Exp. Sta, Columbus, O.
John Reiser, Ohio Power Company, Dover, O.
H. Kohnke, Soil Scientist, Purdue Agri. Exp. Sta., Lafayette, Ind.
E. Stivers, Purdue Agri. Exp. Sta., Lafayette, Ind.
O. B. Riggs, General Manager, Meadowlark Farms, Sullivan, Ind.
J. Hayes, Agricultural Agent, Illinois Central System, Paducah, Ky.
James W. Bristow, Sec.-Treas. Illinois Coal Strippers Assn., Chicago, Ill.
Louis S. Weber, Land Use Eng'r., Ill. Coal Strippers Assn., Springfield, Ill.
R. D. Lane, C.S.F.E.S., Carbondale Branch, Carbondale, Ill.
A. L. Lang, Agronomist, Ill. Agri. Exp. Sta., Urbana, Ill.
R. R. Snapp, Animal Science, Ill. Agri. Exp. Sta., Urbana, Ill.
F. C. Francis, Animal Science, Ill. Agri. Exp. Sta., Urbana, Ill.
H. G. Russell, Animal Science, Extension, Urbana, Ill.
A. F. Grandt, Agronomist, Ill. Agri. Exp. Sta., Urbana, Ill.
D. Larson, Staff Forester, Ill. Div. of Forestry, Springfield, Ill.
Otto Bauman, Dist. Conservationist, Belleville, Ill.
F. C. Spencer, Cons. Botanist and Plant Pathologist, Lebanon, Ill.
P. N. Seastrom, Farm Manager, DuQuoin, Ill.
J. A. Watt, Farm Adviser, Fulton County, Canton, Ill.
C. W. Rovey, Farmer, Farmersville, Ill.
E. Schilf, Veterinarian, U.S.B.A.I., Canton, Ill.
B. Somers, Farmer, Canton, Ill.
A. H. Truax, Deep Valley Farms, Canton, Ill.
D. H. LaVoi, Deep Valley Farms, Canton, Ill.

TABLE 10. HAY AND FORAGE CROPS: Chemical Composition Over A Period of Years. 3/

Crop	Number of samples.	Average pounds per ton of crop.							
		N	Protein	P	K	Ca	Mg	Fe	Mn
Legumes:									
Alfalfa	50	55.0	344	3.6	24.0	35.0	9.8	.16	.02
Red Clover	50	47.4	296	3.2	26.0	29.4	9.2	.28	.10
Alsike	20	47.0	294	4.2	22.4	26.2	10.6	.30	.09
Lespedeza	50	40.4	252	2.9	18.9	17.0	5.7	.20	.14
Sweet Clover (full bloom)	7	34.4	215	3.0	19.4	42.0	13.4	...	...
Sweet Clover October-November	17	41.4	259	2.2	16.0	27.0	12.4	.30	.20
Sweet Clover April-May	30	69.0	431	6.0	32.0	32.8	11.4	...	...
Ladino			441	7.6		29.2			
Grasses:									
Kentucky Bluegrass	50	29.4	184	3.8	32.8	6.2	4.0	.26	.19
Timothy	50	19.6	122	3.0	31.4	5.6	3.6	.16	.14
Redtop	50	21.2	132	3.4	31.8	8.4	4.4	.18	.43
Orchard Grass	30	19.4	121	3.6	38.0	5.4	4.2	.16	.56
Bromegrass	50	29.4	186	3.4	44.3	8.0	3.0	.12	.24
Big Bluestem	10	21.4	134	3.0	29.6	7.6	4.1	.29	.12

3/ Snider, H. J. - Bulletin 518.

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FUTURE PLANS.

The committee planning the field trip for the summer meeting of the American Society of Agronomy at the University of Illinois has been asked to consider including an inspection stop at one of the locations in western or in southern Illinois where vegetation and reclamation work is being carried on.

Seedings will be made during the following year in which major emphasis will be placed on mixture seedings. Yield measurements, animal gains, and other data will be collected so as to attempt to measure the carrying capacity of various spoil bank pastures.

Plans are being made to again measure animal weights, using both beef cattle and sheep as a method of determining forage yields.

Samples of forage material growing on the spoil banks will again be taken at various times during the growing season so that the chemical composition of the forage may be determined.

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1. Croxton, W. C. "Revegetation of Illinois Coal Stripper Lands" - Ecology Volume IX Number 2, 1928.

2. Odell, R. "How Productive Are the Soils of Central Illinois" - Illinois Agricultural Bulletin 522.

3. Snider, H. J. "Chemical Composition of Hay and Forage Crops" - Illinois Agricultural Bulletin 518, 1946.

4. Tyner, E. H. and Smith, R.M. "The Reclamation of the Strip-Mined Coal Lands of West Virginia with Forage Species" - Soil Science Society of American Proceedings, Vol. 10, p. 429-436, 1945.

NOTE: Tabular material relating to soils and source of seed referred to herein have been separately reproduced in mimeograph form as an appendix to this report and will be supplied upon request.

THE POTENTIALITIES OF REVEGETATING AND UTILIZING AGRONOMIC SPECIES ON STRIP MINED AREAS IN ILLINOIS

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A PROGRESS REPORT

COVERING THE THIRD YEAR OF WORK ON A COOPERATIVE INVESTIGATION

CONDUCTED BY

UNIVERSITY OF ILLINOIS, AGRICULTURAL EXPERIMENT STATION

AND

ILLINOIS COAL STRIPPERS ASSOCIATION

- - - - - - - - - - -

NOTE.

The agreement covering this investigation provides that:- "No account of a cooperative research project shall be published by the sponsor or by any other agency, except upon approval of the division of the University, or head of the department in which the work is being done."

Permission for the reproduction of this report has been granted with the understanding that it is to be released for the confidential information of members of Illinois Coal Strippers Association only, and not to be quoted or released for publication.

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FOREWORD

To Members of Illinois Coal Strippers Association.

Gentlemen:

On February 1, 1947, Illinois Coal Strippers Association entered into an agreement with the Agricultural Experiment Station, University of Illinois, covering a project of cooperative research into the possibilities of revegetating and utilizing grasses and legumes on strip mined areas for stock range and other purposes.

This project estimated to require five years of research in order to arrive at sound conclusions, is now entering upon its fourth year. A progress report covering the first year of operation issued on March 19, 1948 dealt principally with the proposed scope and plan of attack on the problem; a survey of spoil bank soils found throughout the state, and preliminary reports on a number of seeding projects. A second report issued on March 15, 1949 presented further information on spoil bank soil materials, and comparisons of such materials with surface soils found on adjoining land; the adaptation of various forage species to spoil bank soils; the results of preliminary studies of comparative gains made by animals pastured on spoil banks with those pastured on undisturbed blue grass and highly improved grass-legume pasture.

The report herewith presented covers the third year of operation.

AJChristiansen
Secretary-Treasurer

March 6, 1950

AGRONOMY PROJECT

NUMBER: 1003 - Third Annual Report.

TITLE: Agronomic Land Use Research on the Mined Areas of the Stripped Coal Lands of Illinois.

OBJECT: The objectives of the project are to investigate the potentialities of revegetating and utilizing agronomic species on the strip-mined areas in Illinois.

LEADERS: A. L. Lang, R. F. Fuelleman, J. N. Spaeth, and F. C. Francis.

Advisory Committee: -

Dean H. P. Rusk
W. L. Burlison
F. C. Bauer
J. C. Hackleman
J. N. Spaeth
A. J. Christiansen
Louis S. Weber

Agronomist - Alten F. Grandt.

AGRONOMIC LAND USE RESEARCH ON THE MINED AREAS OF THE STRIPPED COAL LANDS OF ILLINOIS

By Alten F. Grandt[1/]

This is the third annual report of progress made on Agronomy Project 1003, a cooperative research project of the University of Illinois Agricultural Experiment Station and the Illinois Coal Strippers Association covering an investigation of the potentialities of revegetating and utilizing agronomic species on strip-mined areas in Illinois. While research on this type of land use is seemingly slow and results in many cases are variable, definite progress has been made since the initiation of the project. The results indicate conclusively that under a scientific approach the major part of the strip-mined lands in Illinois can be converted from unsightly tax liabilities into lands that can be covered with grasses, legumes, and livestock.

Over 1,900 experimental plots have been laid out at 40 different locations on 22 mine properties in 14 counties. Additional plots will be established in 1950. Figure 1 shows the general areas where plots are located.

SOIL ANALYSIS OF SPOIL BANK SOIL MATERIAL:

One-thousand-eighty-two soil samples have been collected and they have all been tested by the University of Illinois soil testing laboratory. Table 1 shows the average amounts of plant nutrients found in the soil material. These tests show the average pH to be 6.9, the average available phosphorus to be 124 pounds per acre, and the average available potassium to be 170 pounds per acre.

The usual pH for agricultural soils ranges from approximately 5.0 to 6.8. A pH of 7.0 is neutral. Varying with the species grown, the minimum

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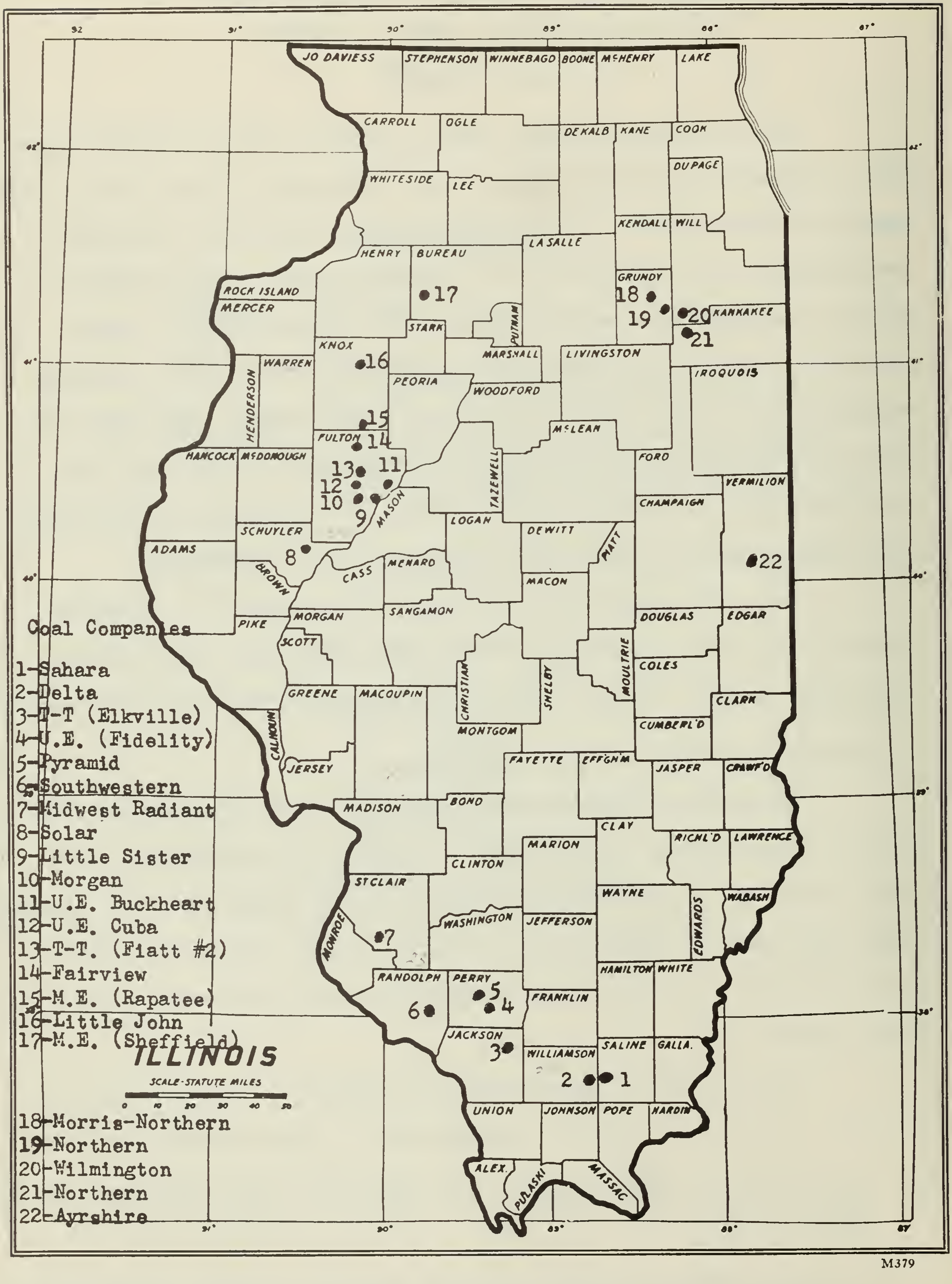
1/ Special Research First Assistant, Soil Experiment Fields and Crop Production, Department of Agronomy, University of Illinois Agricultural Experiment Station, Urbana.

The author acknowledges with thanks the assistance, advice, and encouragement received from Mr. L. S. Weber, Land Use Engineer, Illinois Coal Strippers Association, and Mr. H. J. Snider, Assistant Professor of Soil Fertility, Illinois Agricultural Experiment Station, in conducting these investigations.

AGRONOMY DEPARTMENT, UNIVERSITY OF ILLINOIS, URBANA



Location of Experimental Plots on Strip-Mined Coal Lands of Illinois
(Fig. 1)

Table 1.--Soil Analysis of Spoil Bank Material

Plot locations	County	No. of samples	Acidity average	Phosphorus average	Potassium average	Note
			pH a/	lb. a/	lb. a/	
Southern Illinois						
Sahara	Saline	54	4.5	90	169	Shale + S. S. rock
Delta	Williamson	52	6.2	86	110	
T-T, Elkville (Truax-Traer)	Jackson	20	6.3	58	155	Local acid spots
N. E. Fidelity	Perry	60	6.7	145	204	Local acid spots
Pyramid	Perry	44	7.1	91	154	
Southwestern	Randolph	34	7.3	82	138	Calc. rock
Midwest Radiant	St. Clair	175	7.1	116	131	
Subtotal		438	6.6	105	147	
Western Illinois						
Solar	Schuyler	12	6.8	171	224	High percent
Little Sister	Fulton	28	7.7	157	179	Loess in
Morgan	Fulton	10	7.1	178	230	W. Illinois
U. E., Buckheart	Fulton	36	7.7	101	134	
U. E., Cuba	Fulton	32	7.5	123	144	
T. T., Fiatt	Fulton	93	7.8	146	155	
Fairview	Fulton	44	6.5	133	167	
M. E. Rapatee	Fulton-Knox	81	7.5	148	177	
Little John	Knox	67	6.8	166	194	
Subtotal		403	7.3	140	169	
Northern Illinois						
M. E. Atkinson	Bureau	84	7.4	157	264	Shaly material
Northern Illinois	Grundy	67	6.7	139	198	Shaly material
Morris	Grundy	28	3.1	84	144	Highly acid
Wilmington	Will	22	7.7	55	161	Compact and plastic
Northern Illinois	Kankakee	40	7.6	110	184	Compact and plastic
Subtotal		241	6.8	127	209	
Total and averages		1 082	6.9	122.7	169.2	

a/ pH - 7.0 neutral; P - 92 lb/A, high; K 150 - 200 lb/A high

pH for optimum growth of most agricultural plants ranges between 5.5 and 6.5.

Numerical values for the average mineral content of such highly variable material should be used with reservation. For example, of 20 samples tested in a single two-acre plot the pH varied from 2.7 to 7.1. The average pH was 6.0+. The available potassium content varied from 105 to 300+ pounds per acre, with the average being 186 pounds per acre. Yet only minor shifts have resulted when additional samples are tested and added to the averages. Thus the averages are assumed to be reliably representative. It should be stressed again, however, that in planning the development of an area for a specific use the soil material should be adequately sampled and thoroughly tested. The reaction and mineral content of the soil greatly influence land usage.

SPOIL BANK CLASSIFICATION:

As the result of the reconnaissance survey conducted by the Central State Forest Experiment Station in 1946, strip-mined lands in Illinois have been classified on the basis of the acidity and texture of the soil material(2). These two conditions are considered to be the basic factors that determine potential productivity of spoils and are combined to form the basic spoil types (see Table 2).

Acidity of Spoil Banks:

The acidity of the surface of the spoil banks varies greatly as does the thickness and character of the strata overlying the coal. The overturned strata, each differing in pH value precludes uniformity of soil reaction. In view of this fact, a practical classification of these lands requires a recognition of these varying conditions of acidity. A preliminary classification based on acidity, has been as follows(2):

Table 2.--Area of Strip-mined Land by Acidity and Texture Classes, 1946[a/]

	Acidity class	Texture classes: A. Sands		B. Loams and silty shales		C. Clay		Total	
		acres	percent	acres	percent	acres	percent	acres	percent
1	Toxic. More than 75% of area with pH less than 4.0	0	0	253	.6	163	.4	416	1.0
2	Marginal. 50-75% toxic. Less than 51% with pH 4.0-6.9, and less than 51% with pH 7.0+	0	0	362	.9	173	.4	535	1.3
3	Acid. More than 50% with pH of 4.0-6.9	0	0	2 717	6.8	1 323	3.3	4 040	10.1
4	Calcareous. More than 50% with pH of 7.0 or higher	878	2.2	21 754	54.7	8 662	21.8	31 294	78.8
5	Mixed. Approximately the same proportion of toxic, acid and calcareous areas	1 984	5.0	178	.4	1 373	3.4	3 535	8.8
	Total	2 862	7.2	25 264	63.4	11 694	29.4	39 820	100.0

a/ Central States Forest Experiment Station Technical Paper No. 109. 1948.

1. TOXIC BANKS: These are banks having more than 75 percent of the surface area classified as toxic. Where the pH is less than 4.0 the soil is termed toxic, since a pH of less than 3.8 is lethal to most common economically important plants. Approximately 1.0 percent of the total area stripped in Illinois was classified as toxic.
2. MARGINAL BANKS: Fifty to 75 percent of the area of these banks is toxic, the remainder being acid, calcareous, or mixed. The area classified as marginal was approximately 1.3 percent.
3. ACID BANKS: The reaction of more than 50 percent of the area of these banks was from 4.0 to 6.9. Most agricultural crops grow on soils having a pH of 5.4 or higher. A minimum pH for optimum growth of sweet clover and alfalfa is approximately 6.5.
4. CALCAREOUS BANKS: More than 50 percent of the surface area of these banks has a pH of 7.0 or more. Calcareous soils are suitable for the growth of a wide variety of plants. Approximately 79 percent of the area stripped in Illinois as of 1946 falls in this classification.
5. MIXED BANKS: These banks are so mixed that no acidity class is predominant. By definition less than 51 percent of the area is acid, less than 51 percent calcareous, and less than 50 percent toxic. Patches of toxic, acid, and calcareous are about equal in size, and of such proportions that the area cannot be placed in any of the foregoing classes.

Texture of Soil Materials:

The materials in the overburden overlying the coal include loess, glacial drift, sands, shales, slate, limestone, and sandstone rocks. The variation in texture, acidity, and fertility of the spoil surface depends upon

the different kinds of strata overturned. Textural classification of strip-mined lands, therefore cannot be so exacting and detailed as for soils which are usually derived from relatively uniform parent material. However, certain broad textural classes of spoils are recognized and grouped as follows:

A. SANDS: Sandy spoils are composed principally of sand, sandstone, and sandy shales. Sandy spoils are coarse textured, drain rapidly, and have low water retaining capacity. They are usually low in fertility.

B. LOAMS AND SILTY SHALES: These are spoils composed mainly of loamy material and silty shales. This group usually contains rather high amounts of loessial material. Aeration and drainage are good and the fertility level is generally high.

C. CLAYS: Clay spoils are composed largely of clay, the remaining materials being limestones and soft shales. The clay spoils usually have high fertility and water retaining capacity, but because of the high proportion of clay they are rather poorly drained and aerated.

These two factors, namely acidity and texture, were combined to form the basic spoil types. Thus as of 1946, 54.7 percent of the strip-mined lands in Illinois was classified as calcareous loams and silty shales, spoil type 4-B. Similarly, 8,662 acres or 21.8 percent were calcareous clay or spoil type 4-C. The present system is a method of adding organization in classifying a heterogeneous mass of soil material. Changes will be recommended should future studies reveal the present system is inadequate.

FORAGE CROPS SPECIES ADAPTATION STUDIES:

During the past three years, 1,964 plots have been staked out and seed and fertilizer applied. The plots have been observed regularly and

results recorded. Most of the plots are on spoil type 4-B (calcareous loams and silty shales) and on spoil type 4-C (calcareous clays), the two dominant spoil type classes in Illinois. Approximately 70 different species and varieties have been seeded under varying conditions.

Species Adaptation on Newly Mined Spoils:

Table 3 lists the forage and cultivated crop species that have been seeded on the banks. Excellent results have been obtained with the following legumes: Alfalfa, the sweet clovers, red clover, lespedeza, birdsfoot trefoil, yellow trefoil, and Kudzu. Varying success has been obtained with Ladino, alsike clover, and the vetches. Figures 2-5 give a pictorial record of legumes and grasses growing on the banks.

Orchard grass, the tall fescues, redtop, timothy, bromegrass, bluegrass, and ryegrass have been the grasses that are best adapted. Reed canary grass, western wheatgrass, side-oat grama, love grass, Canadian wild rye, tall meadow oatgrass, Rhodes grass, the native grasses such as big and little bluestem, Indian grass, and switch grass have been established with varying success. The native grasses are very slow to become established. The species that were seeded on the plots in the spring of 1948 first began to show well during the late summer of 1949.

In many instances alfalfa plants growing on the banks have been observed to be rather heavy producers of seed clusters. According to Piper(3) the factors affecting the production of seed are "thickness of stand, a favorable moisture supply and conditions favorable for the tripping of the flowers. Isolated plants produce most seeds. The beneficial effects seem partly due to the increased sunlight received. Abundant moisture lessens seed production, apparently because it stimulates the growth of new sprouts.

Table 3.--Forage Species to Be Seeded

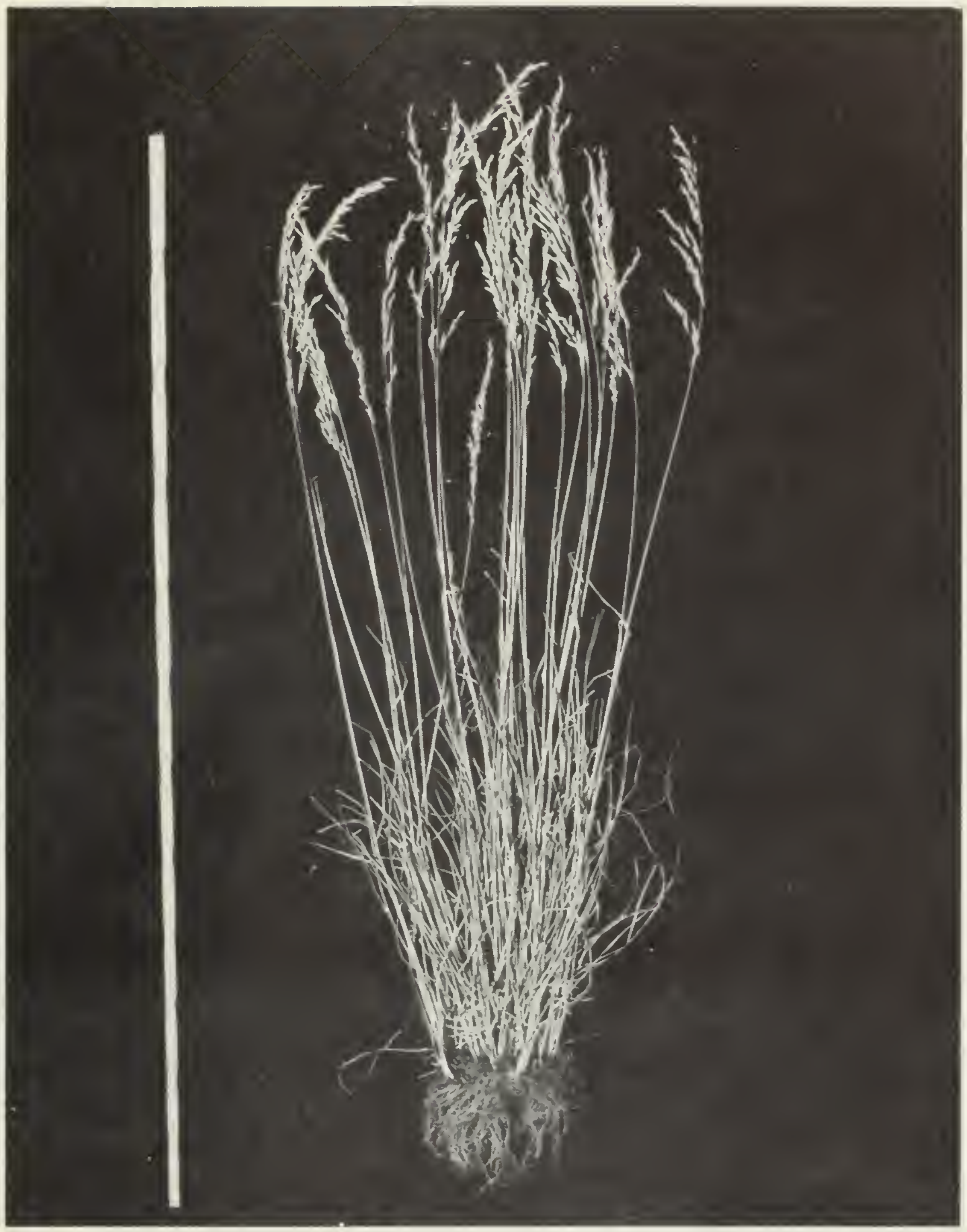
Grasses

Common Name	Botanical Name
Kentucky bluegrass	Poa pratensis
Canada bluegrass	Poa compressa
Big bluegrass	Poa ampla
Canby bluegrass	Poa canbyi
Redtop	Agrostis alba
Timothy	Phlem pratense
Reeds canary grass	Phragmites communis
Orchard grass	Dactylis glomerata
Bromegrass	Bromus inermis leyss
Mountain brome	Bromus marginatus
Meadow fescue	Festuca pratensis
Alta fescue	Festuca pratensis var. alta
Chewings fescue	Festuca rubra
Creeping fescue	Festuca rubra var. creeping
Ryegrass	Lolium perenne
Bermuda grass	Cynodon dactylum
Dallas grass	Paspalum notatum
Crested wheatgrass	Agropyron cristatum
Slender wheatgrass	Agropyron tenerium
Western wheatgrass	Agropyron smithii
Blue grama	Bouteloua gracilis
Side-oat grama	Bouteloua curtipendula
Big bluestem	Andropogon furcatus
Little bluestem	Andropogon scoparius
Buffalo grass	Buchlae dactyloides
Indian grass	Sorghastrum nutans
Tall oatgrass	Arrhenatherum elatius
Canadian wild rye	Elymus canadensis
Michael's grass	
Rhodes grass	Chloris gayana
Switch grass	Panicum virgatum
Meadow foxtail	Alcopecuris eliator
Millets	Setaria sp.
Sudan	Sorghum halapense
Sweet sudan	(Cross) Sorghum halapense x S. vulgare
Love grass	Eragrostis curvula
"M" pasture mix	
Fields pasture mix	
....	Calamagrostis epigea

Table 3.--(cont'd) - Forage Species to Be Seeded

Cultivated Crops

Common Name	Botanical Name
Wheat	Triticum aestivum
Oats	Avena sativa
Rye	Secale cereale
Corn	Zea mays
Soybeans	Glycine max.
Legumes	
Alfalfa	Medicago sativa
Sweet clover - yellow	Melilotus officinalus
Sweet clover - white	Melilotus alba
Hubam clover	Melilotus annula
Spanish sweet clover	Melilotus suaveolus
Evergreen sweet clover	Melilotus
Lespedeza - common	Lespedeza striata
Lespedeza - Korean	Lespedeza stipulacea
Lespedeza - Kobe	Lespedeza striata var.
Lespedeza - Sericea	Lespedeza sericea
Mammoth clover	Trifolium pratense var. perenne.
Alsike clover	Trifolium hybridum
Crimson clover	Trifolium incarnatum
Subterranean clover	Trifolium subterraneum
White Dutch clover	Trifolium repens
Ladino clover	Trifolium repens var. latum
Hop clover	Trifolium procumbens
Alyce clover	Trifolium alyce
Austrian winter pea	Pisum sativa var.
Birdsfoot trefoil	Lotus corniculatus
Big broadleaf trefoil	Lotus uliginosus
Yellow trefoil	Medicago lupulina
Kudzu	Pueraria chunbergiana
Lupines	Lupinus sp.
Lappacea	Trifolium lappaceaum
Red clover, Kenland	Trifolium pratense var.
Red clover, Cumberland	Trifolium pratense var.
Red clover, Midland	Trifolium pratense var.
Sanfoin	Onobrychis vicioefolia
Crown vetch	Vicia sp.
Button clover	Medicago oebicularis
Persian clover	Trifolium reseysinatum
Wagner pea	Lathyrus silvestris wagneri
Singletary pea	
Hairy vetch	Vicia villosa



Alta fescue plant growing on plots on the Delta Collieries property, Williamson county. 1949. (Fig. 2)

Alsike, red clover, and birdsfoot **plants**, (left to right) showing tops and roots, taken from plots on Morgan Coal Company, Fulton county. 1949. (Fig. 3)

Excellent growth of a pasture mixture on the top of a strike-off ridge. Fulton county. 1949. (Fig. 4)

View into plot located on the Delta Collieries property in Williamson county showing several species (from left to right) alfalfa, birdsfoot trefoil, lespedeza, and red clover. 1949. (Fig. 5)

Too little moisture also seriously reduces seed yields." In many areas applications of boron has materially increased the setting of seed(1).

The stand of alfalfa growing on the slopes generally is not as thick as on flat surfaces. The drainage on the slopes of the banks is good. Adequate moisture is present to the deep-rooted legumes at all times. Then too the mineral content of the soil material is favorable for good growth of legumes. Thus the factors essential for seed production are met in the strip-mined soils resulting in greater amount of seed being set than under normal Illinois climatic conditions. Seed was collected from several areas during the 1948 and 1949 growing seasons for germination test. It was observed when threshing the seed that there were many brownish, immature seeds along with the well-developed seeds. Only well-developed seeds were used for the germination tests. The results obtained are presented in Table 4. Many of the hard seeds will germinate. The well-developed seeds thus produced should result in natural reseeding.

Ladino clover, a giant form of common white clover, has given good results in several instances. The forage is high in protein, minerals, and vitamins and is very palatable to livestock. As observed from the plots seeded, Ladino does best in the valleys and rather poorly on southerly and westerly exposed slopes. The reason for this unequal establishment lies in the fact that more moisture accumulates in the low spots, also the higher temperatures on the west and south slopes are less favorable for Ladino clover. Probably for best results Ladino should be hand seeded in the valleys.

Kudzu, a viney, rapid growing, long-lived perennial plant that has been used in the southern part of the United States for pasture purposes has given good results. Acclimated root crowns from a midwestern source have

Table 4.--Results of Germination Tests of Alfalfa Seed[a] Collected From Plants Growing on Strip-Mined Lands in 1949

Location where samples were collected	County	Germination	Hard seed	Dead seed
		perct.	perct.	perct.
4. United Electric Coal Companies Fidelity Mine	Perry	91	7	2
5. Pyramid Coal Corporation	Perry	71	27	2
12. United Electric Coal Companies Cuba Mine	Fulton	70	22	8
13. Truax-Traer Coal Company Fiatt Mine	Fulton	61	39	0
14. Fairview Collieries	Fulton	73	26	1
15. Midland Electric Coal Corporation Rapatee Mine	Knox	63	37	0
19. Northern Illinois Coal Corporation Morris Mine	Grundy	46	48	6
20. Wilmington Coal and Mining Company	Will	48	50	2

a/ The seed was held at below freezing temperatures for approximately 16 hours before germination tests were run. Under Illinois climatic conditions normally very little alfalfa seed is produced. Based on observation the alfalfa growing on the banks produces more seed clusters than alfalfa growing on farm land. The germination percentages listed above compare favorably with germination results listed on seed tags.

proved very adaptable to southern Illinois. Winterkilling was severe in western Illinois. When good survival is obtained this specie will cover the banks rather completely in four to five years. As pasturage Kudzu is recognized as having high feeding value.

Species Seeded in Pre-established Vegetation:

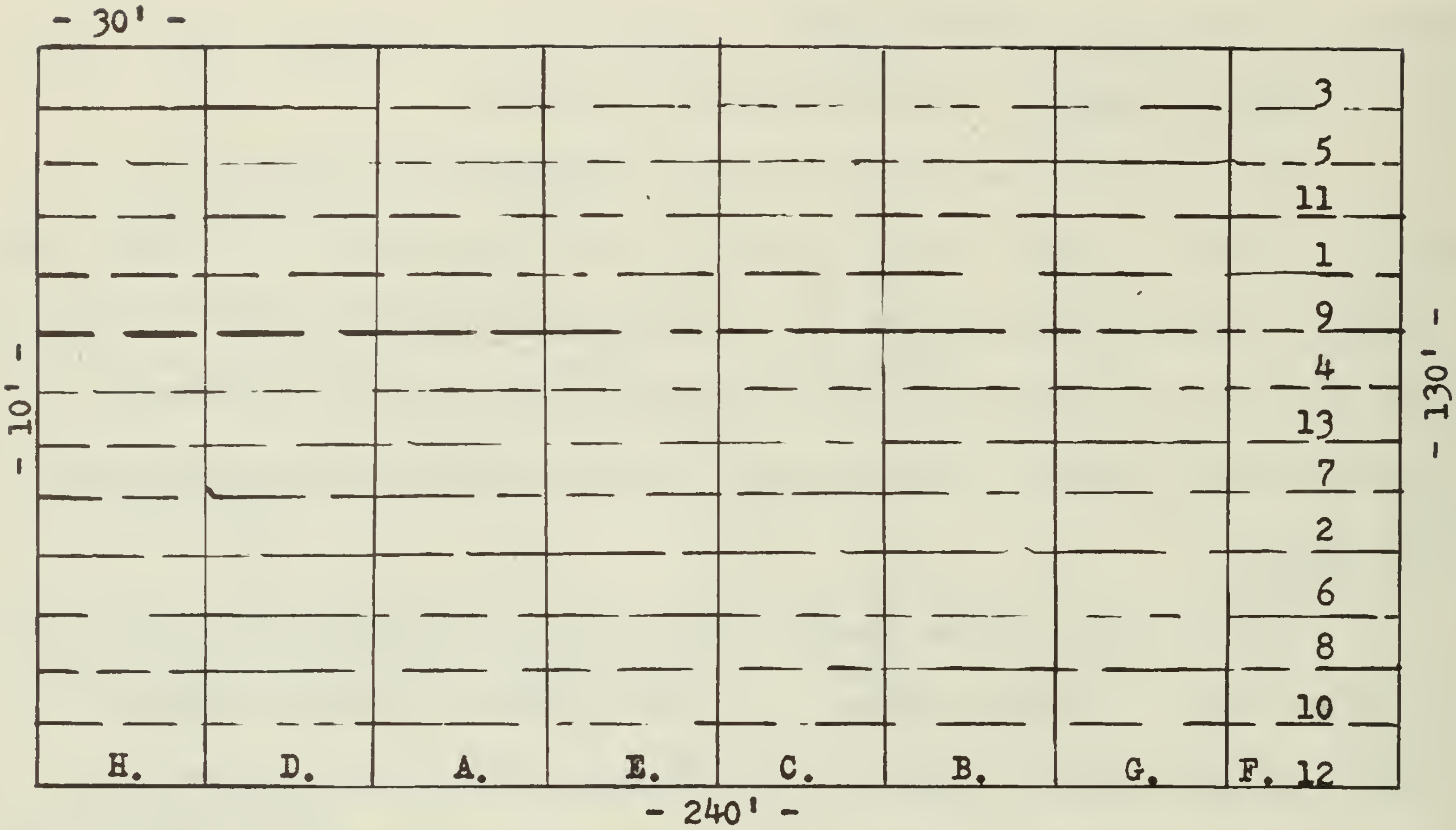
Plots were also staked out on older banks already covered or partially covered by sweet clover, weeds, or other vegetation. The object was to obtain a more desirable mixture by the addition of other species to established sweet clover or to improve the mixture on banks covered mostly with weeds. Approximately 130 plots of this type were seeded in 1948 and 1949 with very little success.

Seeding other legume species into a dense stand of sweet clover was unsuccessful in their establishment. Reseeded grasses seemed to come in only on east or north exposure slopes. Sweet clover, alfalfa, orchard grass, redtop, and timothy were the species most easily established when seeded in to weedy areas.

Fertility Treatment:

The plot design used in this experiment is shown in Figure 6. The fertilizer applications were applied up and down the slopes at the rate of 750 pounds of 8-8-8 mixed fertilizer and 100 pounds of trace mineral fertilizer materials per acre as shown. When limestone was needed (one set of plots, Saline county), it was applied at the rate of 5 tons per acre in the form of hydrated lime. Three locations were treated and seeded in the fall of 1948, while two locations were completed in the spring of 1949.

No response was noted as the result of the application of phosphorus, potassium, and trace minerals. Nitrogen did increase the growth of fall seeded grasses. It also increased weed growth tremendously. Fall applications of nitrogen on newly seeded areas appear to be impractical. The application of



Fertilizer application 750 lb./A	
A	8-8-8
B	8-8-8 plus trace elements
C	8-0-0 plus trace elements
D	8-0-0
E	8-8-0
F	8-0-8
G	0-8-8
H	0-0-0

Forage species seeded	Pounds per plot	Rate per acre
1. Kentucky bluegrass	1.10	15
2. Brome	1.10	15
3. Redtop	1.00	14
4. Timothy	.85	12
5. Orchard grass	1.10	15
6. Alta fescue	1.10	15
7. Ryegrass	1.10	15
8. Sweet clover	1.10	15
9. Alfalfa	1.10	15
10. Red clover	.85	12
11. Ladino	.33	5
12. Lespedeza	1.40	20
13. Birdsfoot trefoil	.45	6

The plot design used for the fertility treatment experiment. (Fig. 6)

nitrogen on old established spoil bank pastures which have reverted principally to grasses may be practical as a means of increasing productive capacity. This problem is being investigated.

Establishment of Mixtures:

Better pastures usually result when a mixture of grasses and legumes is seeded than when a single specie is seeded. Based on plot results the most satisfactory stands of desired species have been obtained by seeding the mixture in the spring of the year on newly mined areas. Fall seeding has not proved satisfactory. At this time it is recommended to seed approximately 60 percent legumes and not more than 40 percent grasses in the mixture.

Mixtures that have been successful and are recommended are:

		lb.		lb.	Total per acre lb.
(1)	Alfalfa	4	Orchard grass	3	
	Lespedeza	4	Alta or K31 fescue	3	
	Sweet clover	3	Timothy	2	
	Ladino	1			20
(2)	Alfalfa	8			
	Lespedeza	4			
	Birdsfoot trefoil	4			
	Orchard grass	4			20
(3)	Alfalfa	4	Orchard grass	4	
	Sweet clover	3	Timothy	3	
	Red clover	3			
	Ladino	1			18
(4)	Alfalfa	10	Bromegrass	5	
	Ladino	1	Orchard grass	3	19

Rate and Time of Seeding:

The time of seeding and age of the banks are very important in obtaining a good pasture cover. Spring seeding on newly mined spoils has been most satisfactory. By seeding all the newly mined banks every year the growth

of undesirable weeds and trees may be reduced because the vegetation seeded competes with the undesirable species. Probably the best time of year to seed in Illinois is late February through March. Poor growth and survival have resulted when the seeding was done as late as April 15.

The rate of application of seed on the banks should be increased about 25 percent over that normally applied to farm land. A minimum of approximately 17 pounds of a mixture is recommended.

Use of Mulching Materials:

Plots were seeded in the spring of 1949 on the compact and plastic till areas in northern Illinois on which strips of straw and manure mulching were applied. Unless some strike-off work is done so that equipment can be used, mulching would be impractical. Results of the effects of the mulching material on the establishment of various species are incomplete at this time.

Use of Cultivated Farm Crops:

Cultivated crops were again seeded on areas that had been leveled. Corn and soybeans planted in May, 1949, in Fulton county, failed. Wheat and rye seeded in the fall of 1948 in Knox county grew to maturity and yields were taken. The results obtained are listed in Table 5. The application of nitrogen only, results in very satisfactory stands of wheat and rye. There has been little or no increase in yield through the application of phosphorus and potassium fertilizers. Quality, as measured by test wieght, may have been increased some.

The yield of rye from a 7.5 acre level plot seeded by one of the companies was 115 bushels, averaging 15.3 bushels per acre.

Horticultural Experimental Plots:

During the 1949 season several horticultural crops were planted on strip-mined lands to determine the growth, survival, and yield on these soils.

Table 5.--Wheat and Rye Yields on Leveled Area

Midland Electric Coal Corporation, Knox County

Treatment - elemental nitrogen		Wheat plots		Rye plots	
Fall[a]	Spring[b]	Yield per acre	Test weight	Yield per acre	Test weight
lb.	lb.	bu.	lb/bu.	bu.	lb/bu.
	20	13.9	58.0	6.9	53.5
20		22.5	57.0	15.1	53.5
40		25.6	58.0	14.8	54.5
40	20	26.8	58.0	19.5	54.0
40	40	27.0	58.5	23.5	55.0
40	60	28.5	58.5	31.2	53.0
40	80	27.2	57.0	24.9	54.5
8-8-8[c]		25.3	58.5	23.8	56.0

a/ Fall application drilled with seed September 24, 1948.

b/ Spring application top-dressed March 25, 1949.

c/ 750 pounds of 8-8-8 commercial fertilizer applied in the fall.

The following vegetable crops were seeded on a leveled and a strike-off area: radishes, beets, carrots, green beans, lima beans, peas, cabbage, cauliflower, tomatoes, watermelon, muskmelon, cucumbers, and sweet corn. Some produce of all the species was realized. Tomatoes, muskmelon, green beans, and cabbage grew best and gave good, edible produce.

DETERMINATION OF FORAGE YIELDS AND QUALITY:

Measurement of Forage Yields:

On seeded areas that have become satisfactorily established, hay yields were obtained. This was done by cutting either two- or four-foot square areas of forage. The forage was dried, weighed, and converted to yields expressed in tons per acre. Table 6 gives the yield of several plots of legumes and mixtures. Alfalfa and birdsfoot trefoil gave the greatest yields during this season. All the legumes were from areas seeded in the spring of 1948. The mixtures represented by Lot 1 and Lot 3, were originally seeded in 1938 and 1947, respectively.

The differences in yields from undisturbed areas (A), strike-off areas (B), or leveled areas (C) were difficult to determine because of the small number of areas other than undisturbed spoils. A thorough study comparing the yields from areas treated in the three ways should be made.

Hay yield data will be helpful in determining the carrying capacity of spoil bank pastures. By comparing these yields with actual grazing conditions more information concerning carrying capacity will be obtained.

Botanical Composition and Ground Cover:

Better stands of desirable vegetation and more complete ground cover are usually obtained on north than on south slope exposures. Similarly botanical counts of forage indicate that vegetation becomes better established on strike-off tops than it does on the tops of the ridges. The point quadrat

TABLE 6. HAY YIELDS OF FORAGE PRODUCED ON SPOIL BANK PLOTS, 1949

Forage specie	Location: Property	Location: County	Type of plots[a]	Yield per acre lb.	Yield per acre tons
Alfalfa	Midwest Radiant	St. Clair	B	7 190	3.6
(3 cuttings)	U.E., Cuba Mine	Fulton	A	7 459	3.75
	M.E. Rapatee	Knox	C	8 223	4.1
Birdsfoot trefoil	U.E. Fidelity	Perry	A	6 037	3.0 +
(3 cuttings)	Midwest Radiant	St. Clair	B	7 015	3.5
	U.E. Cuba	Fulton	A	7 327	3.7
	M.E. Rapatee	Knox	C	7 268	3.6
Sweet clover	Delta	Williamson	A	10 056	5.0
	U.E. Fidelity	Perry	A	1 788	.9
	U.E. Cuba	Fulton	A	5 460	2.7
	M.E. Rapatee	Knox	C	2 354	1.2
Red clover	Midwest Radiant	St. Clair	B	4 408	2.2
	U.E. Cuba	Fulton	A	3 048	1.5
	M.E. Rapatee	Knox	C	5 128	2.6
Yellow trefoil	Delta	Williamson	A	2 496	1.2
	U.E. Fidelity	Perry	A	1 872	.9
	U.E. Cuba	Fulton	A	1 824	.9
Lespedeza	Sahara	Saline	C	3 117	1.6
Korean	Delta	Williamson	A	3 938	2.0 -
	Truax-Traer	Jackson	A	3 795	1.9
	U.E. Fidelity	Perry	A	3 571	1.8
	Pyramid	Perry	A	4 252	2.1
	Southwestern	Randolph	A	3 956	2.0 -
	Midwest Radiant	St. Clair	B	4 722	2.4 -
Early Korean	Midwest Radiant	St. Clair	B	5 784	2.9
Kobe	Midwest Radiant	St. Clair	B	3 636	1.8
Sericea	Midwest Radiant	St. Clair	B	3 408	1.7
Mixtures - on established pastures - (3 cuttings)	B. Somers (Lot 1)	Fulton	A	2 120	1.1
	U.E. Fidelity (Lot 3)	Perry	A	2 911	1.5
	Southwestern	Randolph	A	5 399	2.7

a/ A - undisturbed spoil banks. B - strike-off tops. C - level or partially level.

was used to determine the percent that each specie contributed to the pasture sward and also the percent of the area that was bare. These readings were taken on an established pasture in the spring and again in the fall of 1949.

In the spring the north slope was 91.7 percent covered with vegetation compared to 75 percent for the south slope. There were approximately 15 percent less weeds on the north than on the south exposed slopes.

A similar comparison was made between strike-off tops and the tops of undisturbed ridges. The strike-off tops were 96 percent covered compared to 89 percent covered for the undisturbed tops. Weeds on the undisturbed tops made up approximately 10 percent of the total vegetation compared to 2.5 percent for the strike-off tops. In general, vegetation on strike-off tops contained less weeds and covered the ground more completely than the ungraded tops.

Comparing the results of 1948 and 1949 studies it is evident that the grasses have contributed more to the percent of cover than the legumes during the 1949 season. There is evidence also that the weed population is increasing as would be expected.

Chemical Composition of Forage Species:

This phase of the project, comparing the chemical composition of spoil bank vegetation with that of surrounding farm land, has been looked forward to with a great deal of interest. In 1948 samples of forage were collected from the various spoil types in different locations at various times of the year and the composition determined by chemical analysis. The averages are presented in Table 7. Table 8 (4), which gives the chemical composition of forage crops grown on Illinois farms over a period of years, is presented so that the composition of the forage from the strip-mined lands can be compared with the composition of forage grown on Illinois farm land.

In studying the chemical composition of plants, it is well to keep in mind the influencing factors that may cause variations. Composition may

TABLE 7. CHEMICAL COMPOSITION OF FORAGE CROPS GROWN ON STRIP-MINED LAND IN 1948

Crop	Number of samples	N	Protein	P	K	Ca	Mg
		pct.	pct.	pct.	pct.	pct.	pct.
Legumes:							
Alfalfa	27	2.95	18.4	.20	1.48	1.80	.46
Red clover	26	2.61	16.3	.18	1.47	1.73	.51
Alsike	24	2.88	18.0	.24	1.97	1.55	.51
Ladino	13	2.77	17.3	.22	1.32	1.55	.55
Birdsfoot trefoil	15	2.70	16.9	.19	1.73	1.82	.69
Sweet clover May-June	13	3.41	21.3	.23	1.29	1.74	.44
Sweet clover September-October	11	3.03	18.9	.20	1.35	1.21	.47
Lespedeza, Korean	24	2.02	12.5	.22	1.15	1.13	.33
Mammoth red clover	6	3.05	19.1	.19	2.10	1.54	.49
White clover	8	3.10	19.2	.24	.97	1.75	.55
Hubam	7	2.79	17.5	.21	.83	1.65	.58
Yellow trefoil	8	2.80	17.7	.21	1.70	2.05	.47
Lespedeza, Kobe	6	1.76	11.0	.18	1.20	1.07	.33
Lespedeza, Sericea	3	2.17	13.6	.18	....	1.09	.33
Crimson clover	2	2.70	16.9	.16	1.52	2.10	.36
Button clover	1	2.10	13.1	.22	1.05	1.24	.56
Lappacea clover	1	1.40	8.8	.18	.85	1.82	.60
Austrian winter pea	1	3.80	23.8	.25	2.12	1.30	.30
Grasses:							
Bromegrass	6	2.05	12.8	.29	2.30	.51	.25
Kentucky bluegrass	6	1.44	9.0	.23	1.56	.37	.24
Orchard grass	9	1.86	11.6	.27	2.44	.54	.36
Timothy	6	1.79	11.4	.28	2.27	.38	.22
Redtop	7	1.44	9.0	.17	1.64	.45	.30
Ryegrass	6	1.90	11.7	...	....	.55	.27
Tall fescues	6	1.90	11.9	.28	....	.60	.35
Rhodes grass	5	1.70	10.4	.22	....	.42	.22
Canadian wild rye	4	1.80	11.1	.28	....	.36	.23
Western wheatgrass	2	1.70	10.4	...	....	.56	.27
Love grass	2	1.35	8.4	...	....	.25	.12
Reed canary grass	1	1.90	11.9	.31	....	1.00	.40
Tall oatgrass	1	1.30	8.1	...	....	.60	.40

TABLE 8. HAY AND FORAGE CROPS: Chemical Composition Over a Period of Years.[a]

Crop	Number of samples[b]	N	Protein	P	K	Ca	Mg
		pct.	pct.	pct.	pct.	pct.	pct.
Legumes:							
Alfalfa	50	2.75	17.2	.18	1.25	1.75	.49
Red clover	50	2.37	14.8	.16	1.30	1.47	.46
Alsike	20	2.35	14.7	.21	1.12	1.32	.53
Sweet clover October-November	17	2.07	12.9	.11	.80	1.35	.62
Sweet clover April-May	30	3.45	21.6	.30	1.60	1.64	.57
Lespedeza	50	2.02	12.5	.15	.95	.85	.29
Ladino	50	3.56	22.2	.31	2.24	1.61	.48
Birdsfoot trefoil	6	2.75	17.2	.19	1.50	1.22	.31
Grasses:							
Kentucky bluegrass	50	1.47	9.2	.19	1.64	.31	.20
Timothy	50	.98	6.1	.15	1.57	.28	.18
Redtop	50	1.06	6.6	.17	1.59	.41	.22
Orchard grass	30	.97	6.0	.18	1.90	.27	.21
Bromegrass	50	1.49	9.3	.17	2.21	.40	.15

a/ Snider, H. J. "Chemical Composition of Hay and Forage Crops" Illinois Agricultural Experiment Station Bulletin 518. 1946.

b/ Samples were taken from experiment fields and farms in various parts of Illinois.

vary with the species, stage of growth, climatic conditions, productivity and mineral content of the soil. Internal or external injuries by insects, diseases, rodents, animals, or weather may also affect the composition of vegetation.

Legumes are relatively high in protein and minerals, and for this reason are valuable as a feed. Grasses are lower in protein and certain minerals but are high in others, thus supplying the balance necessary for a good ration.

The influence of the soil material of the strip-mined lands on the chemical composition and feeding value of the forage is revealed by the results of tests made on over 1,000 soil samples. These tests show that Illinois spoil bank soil material is high in phosphorus, potassium, and calcium. This high content of minerals is probably a more logical explanation for the high quality, palatability, and feeding value of the forage grown on the banks than the often suggested possibilities of the rather glamorous trace element theory.

The following quotation supports this thought (5): "Nitrogen, phosphorus, potassium, and calcium are quality elements in feed crops. Classed among the soft elements, they are also chemically active. When soils contain sufficient quantities of the chemically active elements in available form, the crops take them up readily in preference to other less desirable elements which are not so chemically active. A large supply of soft elements tends to improve quality and palatability."

The one element limiting high quality forage production on the banks in Illinois,is nitrogen. However, it can be economically supplied through the use of nodulated legumes or possibly the use of commercial nitrogen.

Animal Gains as a Method of Measuring Yield and Quality:

The quality of forage and the value of strip-mined land for agricultural production may be determined by measuring animal gains through livestock grazing experiments. This is the second year during which two lots of steers have grazed on strip-mined pastures, and the gains compared with gains made by two

lots that grazed on undisturbed land. The grazing tests were carried out on lands owned by Mr. Byron Somers in Fulton county and on lands owned by the United Electric Coal Companies and the Meadowlark Farms, Inc. in Perry county.

Twenty yearling steers of good grade were used in each of the two counties. Ten steers were grazed on spoil bank lands, while the same number were run on ordinary pasture as a check or control group. The control pasture used in Fulton county was an 80-acre bluegrass pasture within a mile of the area grazed by the test group. The control pastures used in Perry county were on improved lands. From April 22 to June 30 the steers grazed on a pasture mixture of timothy, redtop, and Ladino clover. Sudan grass furnished the pasturage from July 1 to July 26, after which the steers were turned onto lespedeza pastures. These pastures were located approximately 20 miles from the test group.

The spoils pasture in Fulton county on which the test was made was the same pasture that was used in 1948. The banks are well covered with good pasture forage. Bluegrass, bromegrass, wild grasses, sweet clover, and alsike clover made up approximately 85 percent of the pasturage species.

The Perry county pasture area is not as well established, having been first seeded in the spring of 1947. Sweet clover, lespedeza, bluegrass, and wild grasses made up most of the forage during the 1949 pasture season.

The results obtained, in terms of animal gains, during the 178-day pasture season were:

	Av. wt. April 20 1/ lb.	Av. wt. Oct. 15 1/ lb.	Av. total gain 1/ lb.	Av. daily gain 1/ lb.
FULTON COUNTY TEST				
Lot 1, test steers, spoils 2/	707	881	174	.98
Lot 2, control steers, bluegrass	704	899	195	1.10
PERRY COUNTY TEST				
Lot 3, test steers, spoils 3/	681	831	150	.84
Lot 4, control steers, improved pasture	712	909	197	1.11

1/ Weights at Urbana, April 20, before the cattle were trucked to their respective pastures and at Urbana on October 15, the day following their return.

2/ Average initial and final weights of 9 steers.

3/ Average initial and final weights of 7 steers.

Table 9 gives the individual weights of each steer before and after the pasture season and shows the difference in individual gains. For the 40 steers the total gain made while on pasture varied from a low of 130 pounds to a high of 250 pounds per head. Figure 7 shows steers utilizing spoil bank pastures.

For the second straight year the animal gains made on the spoil bank pastures were nearly as good as those made on the bluegrass and improved grass-legume pastures. This is gratifying since it definitely shows that the seemingly "waste lands" can be returned to profitable agricultural production.

ECONOMIC INTERPRETATIONS:

Methods, Costs, and Feasibility of Forage Species Establishment:

Several methods are used to seed the strip-mined lands in Illinois. The earliest method used was to seed the forage species by hand seeders. This method is still used. The total labor charge for hand seeding an 80-acre area in 1948 was $1.95 per acre. It required 184 man-hours to seed the 80 acres.

TABLE 9. DATA GIVING INDIVIDUAL WEIGHTS OF STEERS PASTURED IN 1949

Lot 1 -- Spoil bank pastures				Lot 2 -- Bluegrass pasture			
Tattoo	Weight Apr. 20	Weight Oct. 15	Gain on pasture	Tattoo	Weight Apr. 20	Weight Oct. 15	Gain on pasture
Fulton County							
	lb.	lb.	lb.		lb.	lb.	lb.
201	710	860	150	202	750	990	240
205	660	850	190	206	660	880	220
209	720	900	180	210	750	910	160
213	680	870	190	214	690	940	250
217	710	870	160	218	760	970	210
221	770	940	170	222	690	870	180
225	710	940	230	226	660	840	180
229a/	700a/	910a/	190a/	230	710	940	230
233	710	860	150	234	640	780	140
237	690	840	150	238	730	870	140
Averages	707	881	174	Averages	704	899	195
Perry County							
Lot 3 -- Spoil bank pastures				Lot 4 -- Improved grass-legume pasture			
203	690	860	170	204	700	880	180
207	680	820	140	208	750	890	140
211	630	760	130	212	720	960	240
215	770	940	170	216	710	920	210
219	650	760	110	220	770	930	160
223a/	710a/	1 030a/	320a/	224	670	850	180
227	690	850	160	228	670	890	220
231b/	760b/	910b/	150b/	232	740	960	220
235b/	690b/	...b/	...b/	236	710	920	210
239	660	830	170	240	680	890	210
Averages	681	831	150	Averages	712	909	197

a/ Fed corn during part of pasture season. Not included in average.

b/ Part of pasture seasan not on the spoils pasture. Not included in average.

Showing cattle and spoil bank pasture on which Lot 1 cattle grazed. Mr. Byron Somers, Fulton county. (Fig. 7)

They were paid at the rate of 85 cents per hour.

Since 1945 the airplane has been used rather extensively to seed strip-mined areas. The average fee charged has been between 50 to 95 cents per acre. In 1946, 1,500 acres were seeded in 26 hours. The helicopter was first used in 1948 to seed the spoil banks. The rate charged for helicopter service has been 6 cents per pound. Air seeding rates quoted do not include labor costs that are required to inoculate and mix the seed, and load it into the plane. In some cases the pilot is guided by men with flags. These costs must be added to the total costs.

In the spring of 1949 an area was seeded with a power seeder mounted on a farm tractor. During the summer of 1948 the tops of all ridges had been knocked off to a width of 12 to 16 feet. Approximately 250 hours of man labor were required to seed 600 acres of these spoils. Of this total, it required 110 tractor and tractor-man hours, and 66 hours of supervisory time. The remaining labor was used to get the seed ready to be sown. On this job approximately 2.4 acres were seeded per man hour. Operating costs of tractor and seeder must be added to the total costs.

In observing and checking the results of the various methods used, it seems that the most satisfactory stands have been received by hand seeding. "Stripping" or missing of areas has been the common fault of air seeding. Reseeding is then necessary. Even though flagmen are often stationed to guide the plane many pilots evidently do not follow them. In some cases the width of seed spread may not be as wide as had been estimated. The helicopter used in 1949 estimated covering a strip 60-feet each trip. Actually a strip of 45-50 feet was covered adequately. Where mixtures of light and heavy weight seeds are seeded by the air method there is a tendency for the lighter weight seeds to be carried to one side. This is more pronounced on windy days (see Figure 8). Where the tractor mounted seeder was used the valley and lower end of long slopes

Results of air seeding of a bromegrass-alfalfa mixture with the lighter weight bromegrass seeds having drifted to the left side. 1949. (Fig. 8)

were not covered adequately. Where the slopes are long and the ridges far apart the complete ridge is not covered, because the seed cannot be thrown far enough by the seeder. Natural seeding will undoubtedly cover the valleys in time. Where seedling counts were taken the tops had an average of 19 plants per square foot compared to 8 plants per square foot on the sides.

Accessibility After Establishment and Financial Returns:

In developing a mined area for pasture, accessibility throughout the area is of prime importance. Those who have had experience in managing livestock on strip-mine pastures are in accord with the recommendation and need for adequate roadways. The term adequate is extremely relative. Usually too few roadways are made rather than too many.

Limited information indicates that the cost of knocking off the tops of all ridges has varied from approximately $5 per acre for a 12 to 16 foot width to $30 per acre for an approximate 30 foot width. Pasture establishment is more easily accomplished when the tops of all ridges are graded. More study and comparisons regarding costs and advantages gained must be made to determine the facts on this phase of the project.

Advantages of striking off all ridges are: (1) access roadways can be chosen from the highest and best located ridges and maintained as roadways, (2) all the banks are more easily accessible making management practices easier, especially giving better control of livestock, (3) the area can be seeded more easily by hand or power seeders; these methods of seeding have been most satisfactory from the standpoint of stand and ground cover obtained, (4) preliminary botanical counts of forage indicate that vegetation becomes better established on strike-off tops than it does on the tops of the ridges, and (5) vegetation on the strike-off tops contained less weeds than the ungraded tops.

Fencing is a major expenditure required before the lands can be adequately used for pasture. The outside fence should be woven wire. Three strands of four-point barbwire are adequate for division and internal field fences where cattle are to be used.

The use of a Multiflora rose fence is being studied. If the rose will make satisfactory growth and survival, it will be practical to use the rose for extensive fence building on strip-mined lands. On farm land in central Illinois, potentially effective barriers to livestock have been produced after the fourth growing season following installation (6). A comparison of average costs per year of woven wire fence and a living Multiflora rose fence is given in Table 10.

The factor that will determine the extent of development and future use of mined areas is the financial returnsrealized from the use of strip-mined pasture lands. Detailed costs (expenses and receipts) of developed pastures are not available. According to information supplied by the Illinois Coal Strippers Association the net income from a 600-acre unit averaged $7 per acre annually from 1939 to 1945. In 1946 the net income was approximately $9.70 per acre.

Financial returns on these pastures are dependent on the gains made by and price of livestock. Some physical factors or standards are available for estimating probable returns. The average daily gains made by project steers during the 1948 and 1949 pasture seasons have been just over one pound per head. The length of the pasture season the last two years averaged approximately 175 days. Estimates of the carrying capacity of strip-land pastures have varied between 2 to 4 acres per animal unit. Assuming 3 acres per animal unit, one pound gain per day, and a 180-day pasture season, one acre of strip-land pasture will produce 60 pounds of animal gains. If by good management the carrying capacity can be increased to 1 1/2 to 2 acres per animal unit, and the daily gains

TABLE 10. COMPARISON OF AVERAGE COST PER YEAR OF WOVEN WIRE FENCE AND MULTIFLORA ROSE LIVING FENCE[a]

Standard woven wire fence			Multiflora rose living fence		
Cost of Establishment					
320	Rods - woven wire (No. 39-9, 9, 11)	$256.00	3520	1-0 rose seedlings 15" apart at $29/M	$102.08
640	Rods - barbwire, 4 point	38.00	60	Hours labor at 75 cents	45.00
16	Brace posts 8'10" at $1.50	24.00	1	Acre site preparation - plowing, harrowing	25.00
424	Line posts 7', 3 1/2" tops -12' apart at 70 cents	296.80	500	Fill in stock - replanting - 1st year at $29/M	14.50
24	Pounds of staples at 9 cents	2.16	12	Hours labor at 75 cents	9.00
	Man labor and truck at 75 cents per man	96.00	1 1/4	Acres of land at $150/A	187.50
1/2	Acre of land at $150/A	75.00			
	Total for Establishment	$787.96		Total for Establishment	$383.08
Cost of Maintenance					
	Total maintenance and replacement cost (6% of above)	$ 42.77		Yearly depreciation (longevity calculated at 25 years)	$ 15.32
Interest on Investment					
	Annual interest on capital investment (3% simple interest)	$ 23.63		Annual interest on capital investment (3% simple interest)	$ 11.49
Annual Cost					
	Total maintenance and interest on investment	$ 66.40		Total maintenance and interest on investment	$ 26.81

a/ Wandell, W. N. "Agricultural and Wildlife Values of Habitat Improvement Plantings on the Illinois Black Prairie." Reprint From Transactions of the Thirteenth North American Wildlife Conference, March, 1948.

remain at one pound per day, from 90 to 120 pounds of animal gains may be produced per acre. Current prices can then be used to compute probable returns.

More information is needed on the carrying capacity of strip-mined pastures and the average daily gains that can be expected by various grades of cattle for a more thorough understanding of potential returns.

By following a planned, long-range program the costs and problems of establishing a profitable farm unit or organization, the nucleus of which is the strip-mine land, can be greatly reduced. To accomplish this two things need to be done: (1) the lands that do not contain mineable coal, and which make up a part of every mine property, must be improved and maintained as soon as control is acquired, and (2) the mined land must be developed progressively each year and utilized as soon as it is ready to produce. The most concentrated use of these lands will be made in this way, -- by incorporating the spoil banks with surrounding farm land into a well organized farm unit.

DISSEMINATION OF INFORMATION:

A tour through sections of the strip-mined lands in southern Illinois by a small group of members attending the summer meeting of the American Society of Agronomy at the University of Illinois, was conducted on June 16, 1949.

Those attending were:

D. E. Alexander, Graduate Student, University of Illinois, Urbana, Illinois
L. F. Bauman, Illinois Agricultural Experiment Station, Urbana, Illinois
H. P. Boles, Missouri Pacific Railroad, St. Louis, Missouri
R. Jugenheimer, Illinois Agricultural Experiment Station, Urbana, Illinois
J. K. Lindsey, Spencer Chemical Company, Monticello, Illinois
R. Ma, Graduate Student, University of Illinois, Urbana, Illinois
R. Metzger, Graduate Student, University of Illinois, Urbana, Illinois
H. E. Myers, Head, Department of Agronomy, Kansas State College, Manhattan, Kansas
D. Russell, Iowa State College, Ames, Iowa
D. VanAken, Spencer Chemical Company, Wichita, Kansas
L. S. Weber, Illinois Coal Strippers Association, Springfield, Illinois

A paper, Agronomic Research on the Strip Banks in Illinois, was read at the 1949 convention of the National Coal Association which was held October 5-7 in New York City, New York. The paper was in the nature of a progress report on the findings of research conducted by this project.

A brief report was given at the Twenty-First Cattle Feeder's meeting of the results of the 1949 pasture grazing experiment. This was the second year during which two lots of steers grazed on strip-mined pastures, and the gains compared with gains made by two lots that grazed on undisturbed land.

FUTURE PLANS

Many of the phases of the project that are now in progress will be continued and expanded. These will include seedings of species that have given indication of value and require further study, expansion of spoil type studies, forage yield measurements, animal gains, analysis for chemical composition, etc.

In addition more study will be given to the toxic acid condition prevalent in certain areas and the location of material in the highwall that is the source of the sulphur. Infiltration studies have been initiated on the major spoil types that have been treated in different ways. This study is to measure the infiltration on undisturbed spoil banks, strike-off tops, and leveled areas, both bare of vegetation and well vegetated to determine the effect of compaction.

A study of the bacteriological life of the material of the banks is being made. This is to note the difference in the microbiological life of the toxic acid spots compared to that in an area where the vegetation is growing satisfactorily.

More information of an economic nature will be gathered to determine the feasibility and possibilities of using the stripped land along with undisturbed place land.

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THE POTENTIALITIES OF REVEGETATING AND UTILIZING AGRONOMIC SPECIES ON STRIP MINED AREAS IN ILLINOIS

A PROGRESS REPORT

COVERING THE FOURTH YEAR OF WORK ON A COOPERATIVE INVESTIGATION

CONDUCTED BY

UNIVERSITY OF ILLINOIS, AGRICULTURAL EXPERIMENT STATION

AND

ILLINOIS COAL STRIPPERS ASSOCIATION

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SECRETARY-TREASURER

FOREWORD

To Members of Illinois Coal Strippers Association

Gentlemen:

On February 1, 1947, Illinois Coal Strippers Association entered into an agreement with the Agricultural Experiment Station, University of Illinois, covering a project of cooperative research into the possibilities of revegetating and utilizing grasses and legumes on strip mined areas for stock range and other purposes.

This project estimated to require five years of research in order to arrive at sound conclusions, is now entering upon its fifth year. A progress report covering the first year of operation issued on March 19, 1948 dealt principally with the proposed scope and plan of attack on the problem; a survey of spoil bank soils found throughout the state, and preliminary reports on a number of seeding projects. The second report issued on March 15, 1949, and the third report issued on March 6, 1950, presented further information on spoil bank soil materials, and comparisons of such materials with surface soils found on adjoining land; the adaptation of various forage species to spoil bank soils; the results of preliminary studies of comparative gains made by animals pastured on spoil banks with those pastured on undisturbed blue grass and highly improved grass-legume pasture and the utilization of stripped land for pasture.

The report here presented covers the fourth year of operation.

The studies being made during 1951 will complete the program under the agreement and a final report will be issued next year.

A J Christiansen
Secretary-Treasurer

March 1, 1951

AGRONOMY PROJECT

NUMBER: 1003 - Fourth Annual Report.

TITLE: Agronomic Land Use Research on the Mined Areas of the Stripped Coal Lands of Illinois.

OBJECT: The objectives of the project are to investigate the potentialities of revegetating and utilizing agronomic species on the strip-mined areas in Illinois.

LEADERS: A. L. Lang, R. F. Fuelleman, J. N. Spaeth, and R. R. Snapp.

Advisory Committee: -

Dean H. P. Rusk
W. L. Burlison
F. C. Bauer
J. C. Hackleman
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A. J. Christiansen
Louis S. Weber

Agronomist - Alten F. Grandt.

AGRONOMIC LAND USE RESEARCH ON THE MINED AREAS OF THE STRIPPED COAL LANDS OF ILLINOIS

by Alten F. Grandt[1/]

The fourth annual report of progress on Agronomy Project 1003, covering the investigations of the potentialities of revegetating and utilizing agronomic species on strip-mined areas in Illinois is herewith presented. This is a cooperative research project of the University of Illinois Agricultural Experiment Station and the Illinois Coal Strippers Association. The report is an account of progress being made and thus necessarily reviews much of what was stated in previous reports.

The Illinois Coal Strippers Association reports that 46,703 acres of land have been mined by the strip-mining method in Illinois as of January 1, 1950. The acreage mined during 1950 has not been compiled at this time but an estimate of 2,500 acres would bring the total acreage strip mined as of December 31, 1950, to approximately 49,200 acres. Of this acreage 11,246 acres have been planted to trees and there has been a natural encroachment of forest species on 2,500 acres. Approximately 100 acres have been planted to orchard species. Lakes, recreational areas, and state parks utilize approximately 4,000 acres. A greater proportion, approximately 15,600 acres have been seeded for livestock range or pasture use. Thus approximately 15,754 acres or 32 percent of the total land mined in the state has had no treatment or use. This is considered totally unimproved land.

Approximately 40 acres in widely scattered areas have been used for experimental plots in this project. Figure 1 shows the general areas where

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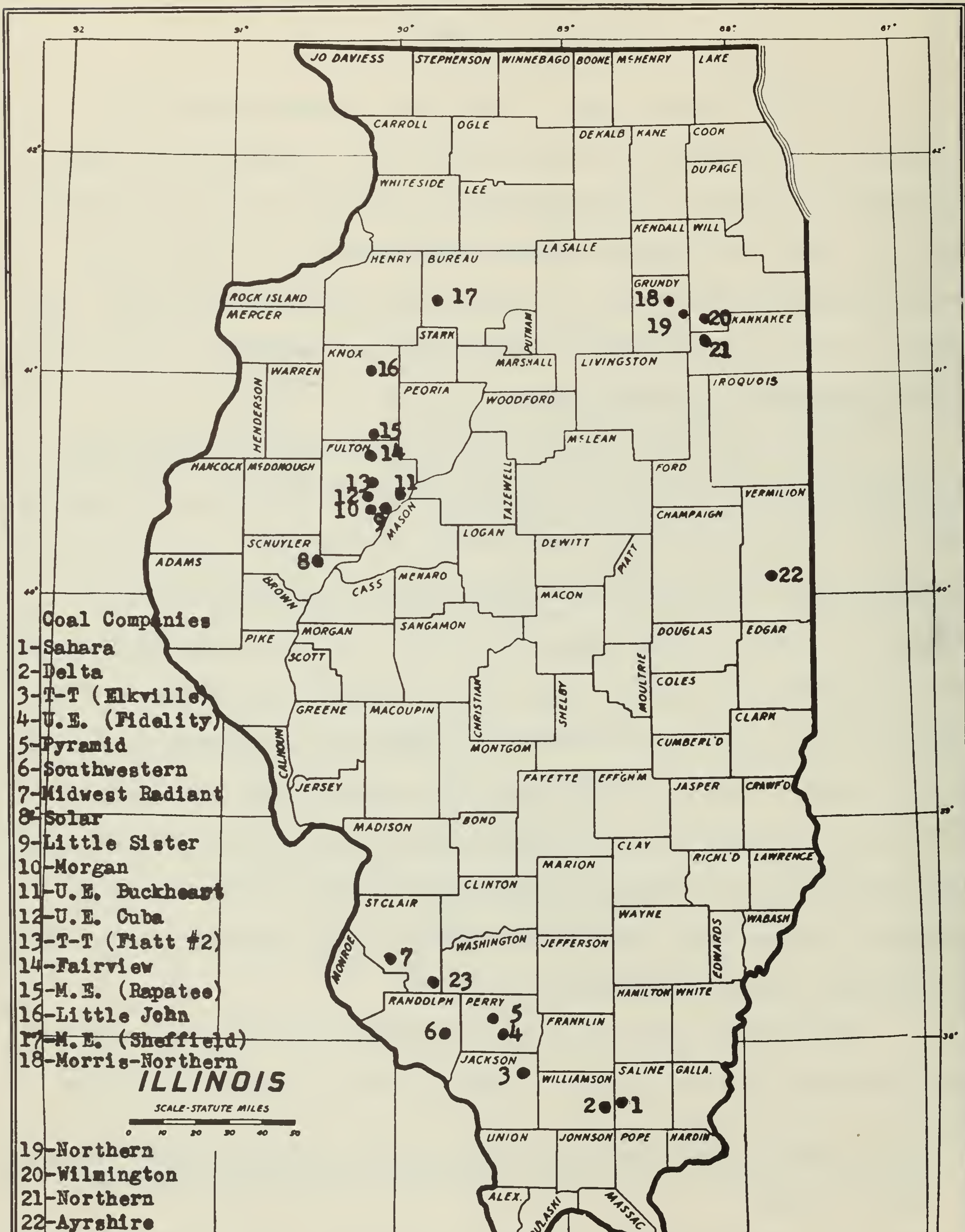
1/ Special Research First Assistant, Soil Experiment Fields and Crop Production, Department of Agronomy, University of Illinois, Agricultural Experiment Station, Urbana.

The author acknowledges with thanks the assistance, advice, and encouragement received from L. S. Weber, Land Use Engineer, Illinois Coal Strippers Association, and H. J. Snider, Assistant Professor of Soil Fertility, Illinois Agricultural Experiment Station, in conducting these investigations.

AGRONOMY DEPARTMENT, UNIVERSITY OF ILLINOIS, URBANA



Location of Experimental Plots on Strip-Mined Coal Lands of Illinois
(Fig. 1)

these plots have been established.

SOIL STUDIES:

Soil Analysis of Strip-Mine Soil Material:

As of December 31, 1950, 1,324 soil samples have been collected from the experimental plot areas and all have been tested by the University of Illinois soil testing laboratory. In addition numerous field tests have been taken. Table 1 shows the average amounts of plant nutrients found in the soil material. The over-all average of these tests show the pH to be 6.96, the available phosphorus to be 130 pounds, and the available potassium to be 172 pounds per acre. Of 684 samples reported on in the first annual report the averages were found to be as follows: pH - 6.8; available phosphorus - 122 pounds; and available potassium - 166 pounds. Several hundred additional tests did not markedly change the over-all averages reported that first year.

In addition to the testing done on the experimental plot areas several areas were sampled on a more extensive basis. The strip-mined soil material of two townships in Knox county was tested. The results of testing 366 soil samples gave an average pH of 7.4, 153 pounds of available phosphorus and 177 pounds of available potassium. These averages are almost identical with the averages reported in Table 1 for western Illinois.

Another block of strip-mined land in southern Illinois was also more extensively studied. The following results in terms of averages were found: the average pH was 6.8, the available phosphorus was 119 pounds, and the available potassium was 152 pounds. These averages are very similar to the average of the 519 samples tested in southern Illinois.

Thus, based on soil reaction or pH and available nutrient content the strip-mined lands in Illinois can be broadly classified as being potentially excellent for the production of forage crops. However, when contemplating

Table 1.— Soil Analysis of Spoil Bank Material

Plot locations	County	Number of samples	Acidity average pH[a]	Phosphorus average lb.[a]	Potassium average lb.[a]	Note
Southern Illinois						
Sahara	Saline	54	4.5	90	169	Shale and S. S. rock
Delta	Williamson	65	6.3	92	134	
T-T Elkville	Jackson	35	6.2	108	177	(Local acid
U. E. Fidelity	Perry	81	6.6	155	208	(spots
Pyramid	Perry	65	7.3	93	160	
Southwestern	Randolph	34	7.3	82	138	
Seminole	St. Clair	10	7.6	126	168	(Loessal
Midwest Radiant	St. Clair	175	7.1	116	131	(
Subtotal and averages		519	6.6	113	155	
Western Illinois						
Solar	Schuyler	12	6.8	171	224	High percent
Morgan	Fulton	10	7.1	178	230	of loess in
Little Sister	Fulton	26	7.7	157	179	W. Illinois
U. E. Buckheart	Fulton	48	7.6	112	133	
U. E. Cuba	Fulton	32	7.5	123	144	
T-T Fiatt	Fulton	93	7.8	146	155	
Fairview	Fulton	54	6.7	144	172	
M. E. Rapatee	Fulton-Knox	120	7.4	157	167	
Little John	Knox	87	6.9	174	192	
M. E. Atkinson	Henry	38	7.3	174	288	
Subtotal and averages		520	7.3	154	177	
Northern Illinois						
M. E. Sheffield	Bureau	76	7.5	145	211	(Shaly
Northern Illinois	Grundy	87	6.9	142	192	(
Morris	Grundy	28	3.1	84	144	Highly acid
Wilmington	Will	32	7.6	56	170	(Compact and
Northern Illinois	Kankakee	40	7.6	110	184	(plastic
Subtotal and averages		263	6.9	121	189	
Eastern Illinois						
Harmattan	Vermilion	22	6.7	58	201	Compact and plastic
Total and averages		1 324	6.96	130	172	

[a] pH - 7.0 neutral; P - 92 lb/A, high; K 150-200 lb/A high

a use for a particular area of strip-mined lands thorough sampling and testing are very important. The reaction and mineral content of the soil material greatly influence land usage and wide variation often occurs within relatively small areas.

Grading of Strip-Mine Land:

There has been much discussion of the pros and cons of grading or leveling in the strip-mine reclamation program. The character of the physical texture of the soil material and the eventual land use are of prime importance when considering grading. In several areas of Illinois the high percentage of loess and glacial till material, the low percentage of rock, the chemical composition of the soil material, and the methods of mining appear to make grading feasible.

The effects of grading on soil structure, on the availability of plant nutrients, and on the growth of forage are being investigated. Two degrees of grading are being considered (1) grading to permit the use of power farm machinery, and (2) topping of the ridges or "strike-off" grading. In strike-off grading there is a minimum amount of compaction due to mechanical equipment, since the bulldozer makes at most only two runs along a ridge. To grade the mined land to the extent that farm power equipment can be used means that the grading equipment passes over the surface many more times. Therefore it is assumed that the compaction resulting from the more complete leveling would probably be greater than in strike-off grading.

One study that is being conducted to determine the effects of grading on soil structure is an infiltration rate. This is the rate at which rain water passes downward into and through the soil. Three physical conditions of the mined land are selected, i.e., (1) undisturbed ridges or banks, (2) strike-off tops, and (3) nearly level, (access by farm equipment). Each of

the three types of physical conditions is analyzed under two phases of vegetation, i.e., well vegetated with legumes, and bare of vegetation. These studies are being carried on in southern and western Illinois on the two major spoil types, namely, calcareous clays and calcareous loams, and silty shales.

The study is incomplete so a full report cannot be made at this time. The work on the undisturbed ridges has not been completed so the comparisons between no grading and strike-off grading or more complete grading or leveling cannot yet be made. However, it has been found that there is no difference in the infiltration rate due to strike-off grading versus more complete grading. This would seem to indicate that the probability of greater compaction on the more completely graded area as mentioned above may be in error or the effect of the greater compaction is very temporary. Vegetation and time after grading does improve the rate of infiltration. Deep-rooted legumes and weathering, such as freezing and thawing and alternate wetting and drying, result in an increased rate of infiltration.

Another study is the effect of grading on the availability of plant nutrients. Table 2 shows the effect of grading on the reaction or pH of the soil material and on the availability of phosphorus and potassium. The effect on reaction or pH was variable. In some cases the pH was lowered by grading. The pH of a calcareous loam soil (loessal) as found on the Midwest Radiant Corporation property was lowered 1 unit from 7.4 to 6.4. Most others were changed to a lesser extent. Conversely on a calcareous clay as found on the Fidelity property the pH was raised. The average pH, however, remained about the same.

Without exception the available phosphorus content was raised as a result of grading. The average increase due to grading was approximately 56 pounds per acre. Several of the areas were raised to 200 pounds plus, so

Table 2.—Effect of Grading on the Soil Reaction and

Availability of Phosphorus and Potassium

Location			Number of samples	pH	P	K	Spoil type
3.	Truax-Elkville	Not graded	20	6.3	58	155	5-C mixed
		Graded (Level)	15	6.0	174	207	clays
7.	Midwest Radiant	Not graded	13	7.4	116	107	4-B calcareous
		Graded (S.O.)[a]	13	6.4	161	125	loams
11.	U. E. Buckheart	Not graded	20	7.7	94	143	4-C calcareous
		Graded (Level)	12	7.3	148	128	clay
13.	Truax-Fiatt	Not graded	28	7.7	144	154	4-C calcareous
		Graded (Level)	15	7.6	200+	191	clay
14.	Fairview	Not graded	12	6.3	131	148	4-B calcareous
		Graded(1)(S.O.)	12	7.5	141	153	loams and
		Graded(2)[b](S.O.)	10	7.3	195	196	silty shales
15.	M. E. Rapatee	Not graded	32	7.8	127	114	4-B calcareous
		Graded (Level)	32	7.1	200+	247	loams and
							silty shales
		Not graded	8	7.7	162	152	4-B calcareous
		Graded (Level)	8	7.8	200+	164	loams and
							silty shales
16.	Little John	Not graded	16	7.2	167	180	4-C calcareous
		Graded (S.O.)	20	7.2	200+	185	clay
17.	M. E. Atkinson	Not graded	26	7.4	152	285	4-B calcareous
		Graded (Level)	38	7.3	174	288	loams and
							silty shales
19.	Northern Illinois	Not graded	5	8.0	151	150	4-B calcareous
		Graded (S.O.)	15	7.2	154	179	loams and
							silty shales
	Over-all average	Not graded	180	7.37	122.4	163.1	
		Graded	190	7.36	179.2	207.7	
	Plus or minus for grading			- .01	+ 56.8	+44.6	

a/ S.O. Strike-off, top of ridge knocked off.

b/ 2 Two different locations graded.

Several mined areas in Illinois are being graded to a more or less level condition. This large, heavy drag was being used on the graded areas to prepare a more suitable seedbed. (Fig. 2)

undoubtedly the total was actually raised more than 56 pounds per acre. The available potassium content fluctuated more but was generally increased as a result of grading. The average increase was 46 pounds per acre.

There may be several explanations for these phenomena: (1) The mechanical breaking of the clay mineral tends to expose the nutrient material and make it temporarily more available. (2) Wetting and drying affects the availability of potassium especially. Thus over a period of time the availability of potassium would be expected to increase even though no grading was involved. (3) Sulphur has the tendency to make phosphorus more available. Perhaps spreading the sulphur around would tend to accomplish this. Spreading the sulphur should tend to lower the pH or make the reaction more acid but there is also much calcium and magnesium present that is being spread as a result of grading which would raise the pH. This study requires a follow-up test to determine if the increased availability is only temporary.

The growth of forage plants on graded areas is probably the best means of measuring the effect of grading. In observing the yields obtained from undisturbed ridges, strike-off ridges and level areas, it can be seen that grading does not hinder vegetative growth. See Table 7. The yield of alfalfa hay from a level area in 1950 was 6 tons per acre. In that particular area the undisturbed mined land yielded 3 tons per acre. As yet an insufficient number of experiments have been setup to thoroughly study the yields that might be obtained from all three degrees of physical conditions of the resulting strip-mine area.

From the studies made on forage growth it seems obvious that grading does not hinder the growth of forage, but rather it has several beneficial effects. Less seed is required per acre, thicker stands are obtained, less weeds are prevalent, and the excess forage material can be more easily

harvested where grading has been done. Kohnke (1) reports that grading permits the soil formed from the raw soil materials to stay in place. Others report that where no grading has been done there is just enough erosion taking place to prevent the crowding out of the legumes due to the grasses becoming sod-bound. This phase of study requires much more time and research before conclusions can be drawn.

Microbiological Studies:

According to Waksman (3) the microscopic plant world is represented in the soil by bacteria, fungi, and algae. Microorganisms are by far the greatest contributors as biological agents of weathering thus participating in soil formation. Three distinct biological processes or functions of microorganisms in the soil are: (1) The decomposition of organic matter, (2) the nitrification or accumulation of nitrates in the soil as a result of the decomposition of organic matter, and (3) nitrogen fixation by symbiotic and nonsymbiotic bacteria.

Legumes seeded on mined lands are inoculated with specific cultures of bacteria and in a symbiotic relationship are able to fix atmospheric nitrogen and supply it to plants in the form of nitrogenous nutrients. Azotobacter are capable of fixing nitrogen nonsymbiotically. Bacteria and fungi are essential in the decomposition of organic matter.

Recently mined soils are presumably very low or void of microorganisms. A study has been initiated to determine in part the nature and extent of the microflora, etc.

A study has been initiated to determine in part the nature of the microflora of the strip-mined soils under various stages of vegetation. Mr. Darrel Lynch, First Assistant in Soil Biology, is conducting this investigation. Table 3 lists the numbers of fungi and azotobacter found.

Table 3.—The Number of Fungi and Azotobacter Found in Strip-Mine Soils Under Different Types of Vegetation

Nature of mined land	Location	Fungi number per gram of soil	Azotobacter
Bare spoils, new	Morgan	10,000	+[a]
Bare spoils, old	Fidelity	No information	++[b]
Alfalfa vegetation	Fidelity	No information	++
Alfalfa vegetation	Midwest Radiant	No information	++
Alfalfa vegetation	Morgan	80,000	++
Alfalfa vegetation	Truax-Fiatt	40,000	None
Bromegrass vegetation	Midwest Radiant	No information	++
Bromegrass vegetation	Morgan	80,000	None
Bromegrass vegetation	Truax-Fiatt	No information	None
Locust tree cover	Fidelity	No information	++
Roadside soil	Fulton county	70,000	+
Urbana area soil	Champaign county	250,000	None

a/ + abundant.

b/ ++ very abundant.

The strip-mined soils covered with bromegrass and alfalfa averaged around 60,000 fungi per gram of soil and the bare areas averaged about 10,000 fungi per gram of soil. A road-side soil under bluegrass sod in Fulton county averaged approximately 70,000 fungi per gram while a highly fertile soil near Urbana, Illinois, averaged about 250,000 fungi per gram. The fairly large number of fungi present under the alfalfa and bromegrass cover shows that with vegetation there is a large increase in numbers of fungi. This would seem to indicate that the soil-forming processes are thus speeded up with an increase in the active organic matter content.

The nitrogen content of these soils, one of the essential constituents of organic matter, is probably further enhanced by the presence of azotobacter species both in the bare spoils and in the areas seeded to alfalfa and bromegrass. It is interesting to note that the bare areas and the alfalfa cover apparently are more conducive to azotobacter growth than was the grass cover. The nature of the microflora as influenced by the type of plant may be a factor affecting azotobacter development. Much further quantitative work however needs to be done concerning the numbers and response of fungi, azotobacter, and other bacteria to crop growth and soil conditions.

FORAGE CROP SPECIES ADAPTATION STUDIES:

The number of experimental plots that have been established is now 2,336. Of this number 999 are located in southern Illinois, 894 in western Illinois, and 443 in the northern Illinois areas. Seventy-one different species and varieties of forage and cultivated crop plants have been used to seed these plots. Table 4 lists the species that have been seeded.

Species Adaptation:

Satisfactory results have been obtained with the following legumes: Alfalfa, sweet clover, red clover, birdsfoot trefoil, lespedeza, alsike,

Table 4.--Forage Species Seeded

Grasses

Common Name	Botanical Name
Kentucky bluegrass	Poa pratensis
Canada bluegrass	Poa compressa
Big bluegrass	Poa ampla
Canby bluegrass	Poa canbyi
Redtop	Agrostis alba
Timothy	Phlem pratense
Reed canary grass	Phragmites communis
Orchard grass	Dactylis glomerata
Bromegrass	Bromus inermis leyss
Mountain brome	Bromus marginatus
Meadow fescue	Festuca pratensis
Alta fescue	Festuca pratensis var. alta
Chewings fescue	Festuca rubra
Creeping fescue	Festuca rubra var. creeping
Ryegrass	Lolium perenne
Bermuda grass	Cynodon dactylum
Dallas grass	Paspalum notatum
Crested wheatgrass	Agropyron cristatum
Slender wheatgrass	Agropyron tenerium
Western wheatgrass	Agropyron smithii
Blue grama	Bouteloua gracilis
Side-oat grama	Bouteloua curtipendula
Big bluestem	Andropogon furcatus
Little bluestem	Andropogon scoparius
Buffalo grass	Buchlae dactyloides
Indian grass	Sorghastrum nutans
Tall oatgrass	Arrhenatherum elatius
Canadian wild rye	Elymus canadensis
Michael's grass	
Rhodes grass	Chloris gayana
Switch grass	Panicum virgatum
Meadow foxtail	Alcopecuris eliator
Millets	Setaria sp.
Sudan	Sorghum halapense
Sweet sudan	(Cross) Sorghum halapense x S. vulgare
Love grass	Eragrostis curvula
"M" pasture mix	
Fields pasture mix	
....	Calamagrostis epigea

Table 4.--(cont'd) - Forage Species Seeded

Cultivated Crops

Common Name	Botanical Name
Wheat	Triticum aestivum
Oats	Avena sativa
Rye	Secale cereale
Corn	Zea mays
Soybeans	Glycine max.
Japanese rose	Rosa multiflora
Legumes	
Alfalfa	Medicago sativa
Sweet clover - yellow	Melilotus officinalus
Sweet clover - white	Melilotus alba
Hubam clover	Melilotus annula
Spanish sweet clover	Melilotus suaveolus
Evergreen sweet clover	Melilotus
Lespedeza - common	Lespedeza striata
Lespedeza - Korean	Lespedeza stipulacea
Lespedeza - Kobe	Lespedeza striata var.
Lespedeza - Sericea	Lespedeza sericea
Lespedeza - Bicolor	Lespedeza tricolor
Mammoth clover	Trifolium pratense var. perenne.
Alsike clover	Trifolium hybridum
Crimson clover	Trifolium incarnatum
Subterranean clover	Trifolium subterraneum
White Dutch clover	Trifolium repens
Ladino clover	Trifolium repens var. latum
Hop clover	Trifolium procumbens
Alyce clover	Trifolium alyce
Austrian winter pea	Pisum sativa var.
Birdsfoot trefoil	Lotus corniculatus
Big broadleaf trefoil	Lotus uliginosus
Yellow trefoil	Medicago lupulina
Kudzu	Pueraria chunbergiana
Lupines	Lupinus sp.
Lappacea	Trifolium lappaceaum
Red clover, Kenland	Trifolium pratense var.
Red clover, Cumberland	Trifolium pratense var.
Red clover, Midland	Trifolium pratense var.
Sanfoin	Onobrychis vicioefolia
Crown vetch	Vicia sp.
Button clover	Medicago oebicularis
Persian clover	Trifolium reseysinatum
Wagner pea	Lathyrus silvestris wagneri
Singletary pea	
Hairy vetch	Vicia villosa

Ladino, yellow trefoil, and Kudzu. Orchard grass, the tall fescues, bromegrass, redtop, timothy, bluegrass, and ryegrass have been the grasses that are best adapted. Reed canary grass, western wheatgrass, side-oat grass, love grass, Canadian wild rye, tall oatgrass, the native grasses, such as big and little bluestem, Indian grass, and switch grass have been established with varying success. The native grasses are very slow to become established.

As reported in a previous report, alfalfa plants growing on strip-mined land have been observed to be heavy producers of seed clusters. Under Illinois climatic conditions normally very little alfalfa seed is produced. An attempt was made to gather information concerning seed yield. Alfalfa was cut for seed production on August 1, 1950, from three different locations. The yields obtained are listed in Table 5. The alfalfa had not been cut or grazed previously but represented the total growth for the season. The yields obtained are phenomenal. However, for the data to be more reliable more samples should be taken. This will be done in 1951.

If level areas are available for seed production of alfalfa, serious consideration should be given to growing and harvesting the crop. Spraying to kill harmful insects is advocated in the seed harvesting program.

Alfalfa varieties of southern origin are being tested on strip-mine soils for winter-hardiness, longevity, and yield. The following varieties were seeded on six different areas: (1) New Mexico Common, Roswell, New Mexico, (2) New Mexico Common, Hatch, New Mexico, (3) India, (4) Advance, and (5) Chilean all from Advance, Arizona. These varieties are being tested against Kansas Common strain and certified Buffalo alfalfa.

Birdsfoot trefoil has continued to show up very well when seeded on strip-mined lands. This specie gives best results when seeded as the only legume plus one or two grasses. In its early stages of growth it does not

Table 5.--Yields of Alfalfa Seed From Strip-Mined Lands in Western Illinois, 1950

Replications	Yield of cleaned seed Spoils	Strike-off tops[a]	Level
	lb./A	lb./A	lb./A
1	372	174	330
2	546	126	342
3	150	156	360
4	504	132	336
Average	390.5	146.5	342
Germination percentage	87 (51 + 36)	84 (39 + 45)	92 (62 + 30)

a/ Seed crop was too mature and had started to shatter when harvested.

Table 6.--Yields of Rye on Level Area in Western Illinois - 1950

Truax-Traer Coal Co., Fiatt Mine

Plot No.	Fertilizer treatment per acre: Fall N	Fall P_2O_5	Fall K_2O	Spring N	Spring P_2O_5	Spring K_2O	Yield per acre: Replications I	Replications II	Average
	lb.	lb.	lb.	lb.	lb.	lb.	bu.	bu.	bu.
1	0	0	0	0	0	0	6.73	4.81	5.77
2	30	60	60	30	0	0	26.19	41.58	33.88
3	30	0	0	60	0	0	34.13	15.38	24.75
4	30	0	0	0	0	0	12.74	15.14	13.94
5	0	30	30	0	0	0	3.61	.....	3.61

compete well with other legumes in a mixture. Seed of Italian origin is readily available. A New York selection, Empire, is also available and is well adapted to strip-mine lands. Approximately 6 to 8 pounds of seed per acre have given satisfactory stands. Inoculation with the Lotus strain of inoculant is necessary for satisfactory results.

Sweet clover, alfalfa, orchard grass, redtop, and timothy were the species most easily established when seeded into preestablished vegetation such as sweet clover or weedy areas.

Establishment of Mixtures:

Better pastures usually result where a mixture of grasses and legumes is seeded than when a single specie is seeded. Based on plot results the most satisfactory stands of desired species have been obtained by seeding the mixture in the spring of the year on newly mined areas.

Some mixtures that have been successful are:

		lb.		lb.	Total per acre lb.
(1)	Alfalfa	4	Orchard grass	3	
	Lespedeza	4	Tall fescues	3	
	Sweet clover	3	Timothy	2	
	Ladino	1			20
(2)	Alfalfa	6	Bromegrass	5	
	Red clover	3	Orchard grass	3	
	Alsike	2			
	Ladino	1			20
(3)	Alfalfa	6	Orchard grass	3	
	Lespedeza	5	Alta fescue	3	
	Ladino	1			18

Use of Grain and Seed Crops:

Grain crops that have been seeded include wheat, rye, oats, Sudan grass, corn, and soybeans. Wheat, rye, and Sudan grass have generally given good results. The yields of rye obtained and the fertilizers applied on a

Alfalfa and bromegrass plants growing on mined land in Fulton county, Truax-Traer Coal Company. These two species are well adapted to mined lands and are valuable forages for livestock production in central and northern Illinois. (Fig. 3)

level area in western Illinois are listed in Table 6. In the past on similar plots nitrogen alone has given the highest yield. On this area it appears that the phosphorus and potassium applied gave an increase in yield over and above the nitrogen needed. According to soil tests taken in this area the available phosphorus and potassium present in the soil was adequate without an additional application. It should be stressed, however, that without nitrogen added the phosphorus and potassium resulted in a very small yield.

A level area of approximately 14 acres was seeded to wheat by one of the coal companies. This wheat averaged 25 bushels per acre; 357 bushels of wheat were harvested from the area. One-hundred and fifty pounds of 3-12-12 were applied per acre. The nitrogen content of this soil material was high, since the soil in this area was a calcareous peaty material.

Excellent growth of Sudan, fertilized with a high nitrogen carrying material, was observed on another extensively leveled area in western Illinois.

Adaptation of Multiflora Rose and Lespedeza Bicolor:

Rosa multiflora has been planted on strip-mined lands and its growth and survival observed. Excellent survival and growth were obtained in western Illinois. After 2 years growth the branches measured from 6 to 8 feet in length. Best results were obtained when a manure mulch and a small amount of ammonium nitrate was applied at planting time. The plants were planted in two rows about 18 inches apart with 12 to 18 inch spacing of plants within the row.

If the rose will make satisfactory growth and survival, it will be practical to use it for extensive fence building on strip-mined lands. Planting it on the top of ridges that have been knocked off appears to be practical. Interior fencing can be built by this means. The rose must be protected from livestock for some time after planting because livestock will eat off the tips of the branches and retard the growth. This rose also makes excellent wild life cover.

Lespedeza bicolor, a shrubby type of plant used for wild life (quail) food, was first seeded on the strip-mine land in 1948. The seed was obtained from the Natural History Department, Wildlife Division, of Georgia. The stand obtained was not too good but many plants were established. Seed was produced in 1949 and 1950. This specie grows better in southern than in western Illinois.

Collection of Naturally Introduced Species:

To obtain information about the nature of plants that can be found growing on strip-mined land a plant collection was started in 1950. This collection did not include trees, but was predominantly of herbaceous plants. A total of 158 different plant species was collected, mounted, and identified. Fifty-three of these had been seeded and were considered to be artificially introduced, while the remainder, 105 species, were considered as being naturally introduced species. Thirty-four different plant families were represented by these species. The families represented most often were the Composite family with 19 species, the Grass family with 14 naturally introduced and 32 artificially introduced species, the Pea family with 5 naturally introduced and 21 artificially introduced species, and the Buckwheat family with 5 species.

The list is not complete but does represent the plants seen most often and are rather commonly found on strip-mined lands. The collection will be continued in 1951.

DETERMINATION OF FORAGE YIELDS AND QUALITY:

Measurement of Forage Yields:

On seeded areas that have become satisfactorily established, hay yields have been obtained. This was done by cutting either two or four-foot square areas of forage. The forage was dried, weighed, and converted to

yields expressed as pounds and tons per acre. Table 7 gives the hay yields of forage produced on strip-mined lands in 1950.

Alfalfa yields were taken at seven different locations with several replications at each location. The average yield obtained was 7,067 pounds or 3.53 tons per acre. The highest yield was obtained in Knox county on a level area. An acre, cut three times, yielded 186 bales or 12,620 pounds or 6.3 tons of hay per acre. The lowest yield of alfalfa was 2.8 tons of hay per acre.

Birdsfoot trefoil was cut at five different locations. The average yield obtained was 6,811 pounds or 3.4 tons of hay per acre. Three cuttings per season were made. Legume mixtures were cut at seven different locations. The average yield, three cuttings per season, was 4,702 pounds or 2.35 tons per acre. The yield of lespedeza cut at nine different locations averaged 3,350 pounds or 1.68 tons of hay per acre. The differences in yields from undisturbed mined areas (A), strike-off ridges (B), and leveled areas (C), are listed. It should be pointed out that the hay yields on strike-off ridges and leveled areas (B and C) were as good or better than yields from undisturbed mined areas (A).

Hay yield data will be helpful in determining the carrying capacity of strip-mined pastures. By comparing these yields with actual grazing conditions more information concerning carrying capacity will be obtained.

Chemical Composition of Forage Species:

The chemical composition of forage growing on strip-mined land in 1948 and 1949 is presented in Tables 8 and 9. Samples of the various forages were collected from the several spoil types at different locations and at various times of the year. Most species were sampled at the bloom stage of growth.

Table 7.--Hay Yields of Forage Produced on Spoil Bank Plots, 1950

Forage specie	Number of samples	Location: Property	Location: County	Type of plots[a]	Yield per acre lb.	Yield per acre tons
Alfalfa	12	Delta	Williamson	A	6 444	3.2
plus grasses	8	Pyramid	Perry	A	5 489	2.8
(3 cuttings)	6	Midwest Radiant	St. Clair	B	6 969	3.5
	4	Morgan	Fulton	A	6 422	3.2
	4	Cuba	Fulton	A	5 520	2.8
	6	Midland Electric	Knox	A	6 007	3.0
1 acre	186 bales	Midland Electric	Knox	C	12 620	6.3
Average yield					7 067	3.53
Birdsfoot trefoil	8	Delta	Williamson	A	6 566	3.3
plus grasses	8	Pyramid	Perry	A	5 386	2.7
(3 cuttings)	2	Midwest Radiant	St. Clair	B	8 688	4.2
	3	Morgan	Fulton	A	5 668	2.8
	4	Cuba	Fulton	A	7 746	3.9
Average yield					6 811	3.4
Ladino (3 cuttings)	3	Morgan	Fulton	A	5 968	3.0
Lespedeza	2	Sahara	Saline	C	3 942	2.0
(1 cutting)	14	Delta	Williamson	A	2 664	1.3
	2	T-T Elkville	Jackson	A	3 780	1.9
	2	T-T Elkville	Jackson	B	4 524	2.3
	2	T-T Elkville	Jackson	C	3 708	1.9
	2	Fidelity	Perry	A	3 504	1.8
	6	Pyramid	Perry	A	2 010	1.0
	3	Midwest Radiant	St. Clair	B	4 672	2.3
	3	Morgan	Fulton	A	1 350	.7
Average yield					3 350	1.68
Legume mixtures	4	Delta	Williamson	A	4 680	2.3
(3 cuttings)	5	Pyramid	Perry	A	4 807	2.4
	5	Southwestern (old)	Randolph	A	4 462	2.2
	4	Southwestern (new)	Randolph	A	4 057	2.0
	3	Morgan	Fulton	A	5 874	2.9
	7	B. Somers (Lot 1)	Fulton	A	3 876	2.0
	11	T-T Fiatt	Fulton	A	5 160	2.6
Average yield					4 702	2.35

[a] A - undisturbed spoil banks. B - strike-off tops. C - level or partially level.

Table 8.--Chemical Composition of Forage Crops Grown on Strip-Mined Land in 1948

Crop	Number of samples	N	Protein	P	K	Ca	Mg	Mn	Si
		pct.	pct.	pct.	pct.	pct.	pct.	pct.	pct.
Legumes:									
Alfalfa	29	2.99	18.7	.21	1.56	1.87	.49	.0066	....
Yellow trefoil	8	2.85	17.8	.21	1.70	2.05	.47	.....	....
Birdsfoot trefoil	14	2.75	17.2	.20	1.76	1.81	.71	.0111	....
Birdsfoot trefoil (N.Y.)	3	2.29	14.3	.17	1.58	1.87	.61	.0188	....
Red clover	27	2.67	16.7	.18	1.48	1.68	.49	.0087	....
Mammoth red clover	6	3.50	21.9	.19	2.10	1.54	.49	.....	....
Ladino	13	2.85	17.8	.23	1.46	1.42	.49	.....	....
Alsike	24	2.90	18.1	.24	1.97	1.55	.50	.0144	....
White Dutch clover	8	3.10	19.2	.24	.97	1.75	.55	.....	....
Sweet clover, 1st year									
June-August	16	3.54	22.1	.22	1.31	1.84	.57	.0089	....
September-November	12	3.31	20.7	.23	1.15	1.41	.54	.0092	....
May-June, 2nd year	13	2.88	18.0	.23	1.44	1.56	.41	.0075	....
Hubam	7	2.85	17.8	.22	1.70	2.05	.47	.....	....
Lespedeza, Korean	21	2.11	13.2	.24	1.18	1.10	.33	.0085	....
Lespedeza, Kobe	7	1.79	11.3	.20	1.22	1.07	.32	.0100	....
Lespedeza, Sericea	3	2.21	13.8	.18	....	1.09	.33	.0062	....
Crimson clover	2	2.73	17.1	.16	1.52	2.14	.36	.....	....
Button clover	1	2.16	13.5	.22	1.05	1.24	.56	.0175	....
Lappacea clover	1	1.42	8.9	.18	.85	1.82	.60	.0360	....
Austrian winter pea	1	3.88	24.3	.25	2.12	1.30	.30	.0010	....
Grasses:									
Kentucky bluegrass	6	1.49	9.3	.23	.78	.36	.23	.0093	1.19
Bromegrass	4	2.00	12.5	.28	2.25	.51	.56	.0154	1.89
Orchard grass	4	1.96	12.3	.29	2.90	.49	.38	.0244	2.15
Tall fescues	3	1.78	11.1	.31	....	.51	.31	.0200	2.32
Timothy	6	1.84	11.5	.28	2.27	.38	.24	.0092	1.00
Redtop	6	1.46	9.1	.17	1.68	.44	.28	.0160	2.68
Ryegrass	6	1.88	11.7	.25	....	.56	.26	.0125	2.51
Canadian wild rye	4	1.78	11.1	.29	....	.36	.23	.....	....
Western wheatgrass	2	1.66	10.4	.27	....	.56	.27	.0130	4.02
Love grass	2	1.39	8.7	.15	....	.24	.12	.0100	1.77
Rhodes grass	3	1.51	9.4	.23	....	.51	.20	.....	....
Tall oatgrass	1	1.38	8.6	.10	....	.56	.44	.0215	2.93
Sweet Sudan	2	1.18	7.4	.19	....	.55	.25	.0065	4.44
Michaels grass	1	1.84	11.5	.24	....	.36	.15	.0065	1.19

Table 9.— Chemical Composition of Forage Crops Grown

on Strip-Mined Land in 1949

Crop	Number of samples	N	Protein	P	K	Ca	Mg
		pct.	pct.	pct.	pct.	pct.	pct.
Legumes:							
Alfalfa	19	2.80	17.5	.21	1.71	1.35	.38
Yellow trefoil	7	3.10	19.4	.26	2.22	1.26	.60
Birdsfoot trefoil	21	2.53	15.8	.22	1.75	1.16	.53
Birdsfoot trefoil (N.Y.)	2	2.20	13.8	.23	1.77	1.28	.54
Red clover	14	2.58	16.1	.18	1.93	1.28	.43
Mammoth red clover	4	2.11	13.2	.17	1.27	1.26	.57
Ladino	19	3.27	20.4	.24	2.18	1.46	.57
Alsike	15	2.91	18.2	.23	2.23	1.05	.58
Sweet clover, 1st year							
July-August	10	3.39	21.2	.22	1.94	1.41	.59
September-November	10	2.78	17.4	.20	1.31	1.00	.50
May-June, 2nd year	13	3.01	18.8	.22	1.89	1.20	.57
Hubam	6	3.17	19.8	.35	1.69	1.10	.53
Lespedeza, Korean	8	2.09	13.1	.18	.89	.84	.28
Lespedeza, Kobe	1	1.90	11.9	.13	.70	.82	.24
Lespedeza, Sericea	3	1.72	10.8	.15	.79	.67	.23
Kudzu leaves	1	2.24	14.0	.42	2.60	.60	.44
Grasses: (Hay stage)							
Kentucky bluegrass	3	1.76	11.0	.24	1.84	.37	.25
Bromegrass	4	1.40	8.8	.15	2.35	.40	.22
Orchard grass	7	1.51	9.4	.25	2.44	.43	.29
Alta fescue	6	1.43	8.9	.19	1.94	.40	.33
Timothy	4	1.57	9.8	.20	2.09	.36	.21
Redtop	7	1.15	7.2	.17	1.34	.44	.25
Tall oatgrass	2	1.05	6.6	.21	2.13	.25	.24
Little bluestem	1	.60	3.8	.14	.80	.30	.13
Big bluestem	1	.60	3.8	.15	.62	.30	.13
Switch grass	1	.82	5.1	.12	.55	.70	.34

In studying the chemical composition of plants, it is well to keep in mind the influencing factors that may cause variations. Composition may vary with the species, stage of growth, climatic conditions, productivity and mineral content of the soil. Internal or external injuries by insects, diseases, rodents, animals or weather may also affect the composition of vegetation.

Legumes are relatively high in protein and calcium and for this reason are highly valuable as a feed. Grasses are lower in protein and certain minerals, but are high in carbohydrates supplying the balance necessary for a good ration.

Table 10 gives the comparison of the chemical composition of several forage species grown on strip-mined land in 1948 and in 1949 with the forage grown on Illinois farms. The nitrogen and protein content of the strip-mine forage for both years is higher than that grown on Illinois farms for alfalfa, red clover, first year sweet clover, lespedeza, Kentucky bluegrass, and orchard grass. The nitrogen and protein content of the Ladino grown on strip-mine lands had been markedly lower than that grown on Illinois farms. It has been difficult to get good stands of Ladino growing on the strip-mine lands. The growth in 1950 appeared better than in previous years.

With regard to phosphorus the chemical composition of strip-mine forage has been very high. The tests of strip-mine soil material show that the available phosphorus content is very high so it is expected that this element would be high in the forage. The potassium, calcium, and magnesium content of the strip-mine forages compare very favorably with that grown on Illinois farms.

A study to determine the chemical composition of several species during different months of the year was started in 1949. The species studied

Table 10.—Comparison of the Chemical Composition of Several Forage Species Grown on Strip-Mined Land in 1948 and 1949 With That Grown on Illinois Farms[a]

Crop	Number of samples	N	Protein	P	K	Ca	Mg	Mn
		pct.	pct.	pct.	pct.	pct.	pct.	pct.
Alfalfa								
1948	29	2.99	18.7	.21	1.56	1.87	.49	.0066
1949	19	2.80	17.5	.21	1.71	1.35	.38	.0022
B-518[a]	50	2.75	17.2	.18	1.25	1.75	.49	.0100
Red clover								
1948	27	2.67	16.7	.18	1.48	1.68	.49	.0087
1949	14	2.58	16.1	.18	1.93	1.28	.43	.....
B-518[a]	50	2.37	14.8	.16	1.30	1.47	.46	.0500
Ladino								
1948	13	2.85	17.8	.23	1.46	1.42	.49	.....
1949	19	3.27	20.4	.24	2.18	1.46	.57	.0016
B-518[a]	50	3.56	22.2	.31	2.24	1.61	.48	.0055
Birdsfoot trefoil								
1948	14	2.75	17.2	.20	1.76	1.81	.71	.0111
1949	21	2.53	15.8	.22	1.75	1.16	.53	.0040
B-518[a]	6	2.75	17.2	.20	1.50	1.22	.31	.....
Sweet clover, 1st year								
1948 (September-November)	12	3.31	20.7	.23	1.15	1.41	.54	.0092
1949 (September-November)	20	3.09	19.3	.21	1.63	1.31	.55	.0040
B-518[a] (October-November)	17	2.07	12.9	.11	.80	1.35	.62	.1000
Sweet clover, 2nd year								
1948 (May-June)	13	2.88	18.0	.23	1.44	1.56	.41	.0075
1949 (May-June)	13	3.01	18.8	.22	1.89	1.20	.57	.....
B-518[a] (April-May)	30	3.45	21.6	.30	1.60	1.64	.57	.....
Lespedeza								
1948	21	2.11	13.2	.24	1.18	1.10	.33	.0085
1949	8	2.09	13.1	.18	.89	.84	.28	.....
B-518[a]	50	2.02	12.5	.15	.95	.85	.29	.0700
Kentucky bluegrass								
1948	6	1.49	9.3	.23	.78	.36	.23	.0093
1949	3	1.76	11.0	.24	1.84	.37	.25	.0111
B-518[a]	50	1.47	9.2	.19	1.64	.31	.20	.0950
Bromegrass								
1948	4	2.00	12.5	.28	2.25	.51	.56	.0154
1949	4	1.40	8.8	.15	2.35	.40	.22	.0096
B-518[a]	50	1.49	9.3	.17	2.21	.40	.15	.1200
Orchard grass								
1948	4	1.96	12.3	.29	2.90	.49	.38	.0244
1949	7	1.51	9.4	.25	2.44	.43	.29	.0182
B-518[a]	30	.97	6.0	.18	1.90	.27	.21	.2800
Tall fescues								
1948	3	1.78	11.1	.31	....	.51	.31	.0200
1949	6	1.43	8.9	.19	1.94	.40	.33	.0103
B-518[a]	5	1.45	9.1	.24	1.74	.35	.22	.0047

[a] Snider, H. J. "Chemical Composition of Hay & Forage Crops". Illinois Agricultural Experiment Station Bulletin 518. 1946.

were alfalfa, Ladino clover, orchard grass, bromegrass, and Alta fescue. The results obtained and a comparison, where possible, with the forage grown on Illinois farm soils are presented in Tables 11, 12, and 13.

In alfalfa, the nitrogen and protein content was lowest during the months of July and August and highest during the fall months. The phosphorus content of the alfalfa on strip-mine lands was universally as high or higher than the alfalfa grown on Illinois farms. In general the chemical composition of the alfalfa grown on strip-mine lands compared very favorably with that grown in other areas of Illinois.

A comparison of the composition of Ladino clover is given in Table 12. The nitrogen and protein content is lowest during the month of July. In studying Table 12 it is observed that the nutrient content of the several elements is quite high. The top growth of Ladino clover is largely leaves with the stems making up a small percentage of total growth. The composition of alfalfa leaves listed in the table shows that the nutrient level of leafy alfalfa is also very high. Both of these species make excellent feed, which is emphasized by the data listed in Tables 11 and 12.

Table 13 lists the chemical composition of three grass species growing on strip-mined lands at six different times of the year during 1949. Orchard grass and Alta fescue are earlier maturing species than bromegrass. This accounts in part for the fact that the bromegrass is higher in protein content than the other two grasses. These grasses were growing in legumes which is their principal source of nitrogen. From this data it appears that the nitrogen requirement of the grasses is met by the legumes.

Composition of Tops and Roots of Six Legume Species:

A number of plants were dug during the 1949 season and the tops and roots were analyzed separately. The composition of the tops and roots of

Table 11.—Chemical Composition of Alfalfa During

Seven Months of the Year

Location	Year	Month	Number of samples	N	Protein	P	K	Ca	Mg	Mn
				pct.	pct.	pct.	pct.	pct.	pct.	pct.
Strip Mine	1948	May	3	3.11	19.4	.19	1.62	2.91	.54	.0090
Strip Mine	1949	May	6	3.17	19.8	.22	1.88	1.85	.58	.0028
Univ. of Ill.[a]	1948	May	3	2.56	16.0	.13	1.34	2.00	.49	.0065
Strip Mine	1948	June	3	3.25	20.3	.23	1.35	2.07	.45	.0066
Strip Mine	1949	June	7	2.59	16.2	.19	1.67	1.27	.38	.0030
Univ. of Ill.[a]	1948	June	3	3.06	19.1	.14	1.59	1.33	.47	.0070
Strip Mine	1948	July	6	2.97	18.6	.20	1.53	1.74	.59	.0064
Strip Mine	1949	July	6	2.70	16.9	.19	1.86	1.10	.39	.0023
Univ. of Ill.[a]	1948	July	2	3.02	18.9	.20	1.44	1.78	.52	.....
Strip Mine	1948	August	5	2.65	16.6	.19	1.46	1.73	.49	.0068
Strip Mine	1949	August	2	3.40	21.3	.30	2.05	1.21	.36	.0014
Univ. of Ill.[a]	1948	August	3	3.35	20.9	.21	2.17	1.31	.40	.0070
Strip Mine	1948	September	3	3.48	21.8	.28	1.78	1.77	.39	.0025
Strip Mine	1949	September	4	3.39	21.2	.25	1.99	1.26	.31	.0021
Univ. of Ill.[a]	1948	September	1	2.81	17.6	.20	.81	1.46	.56	.....
Strip Mine	1948	October	3	3.30	20.6	.22	1.81	1.67	.41	.0098
Strip Mine	1949	October	5	3.99	24.9	.30	2.57	1.18	.35	.0015
Univ. of Ill.[a]	1948	October	.	....	....	...	....	....	...	.....
Strip Mine	1948	November	.	....	....	...	....	....	...	.....
Strip Mine	1949	November	4	3.62	22.6	.24	2.01	1.30	.37	.0030
Univ. of Ill.[a]	1948	November	3	2.83	17.7	.17	1.35	1.24	.40	.0249
Strip Mine	1948	Average	29	2.99	18.7	.21	1.56	1.87	.49	.0066
Strip Mine	1949	Average	19	2.80	17.5	.21	1.71	1.35	.38	.0022
B-518[b]	1948	Average	50	2.75	17.2	.18	1.25	1.75	.49	.0100

[a] Snider, H. J. Unpublished data.

[b] Snider, H. J. "Chemical Composition of Hay & Forage Crops". Illinois Agricultural Experiment Station Bulletin 518. 1946.

Table 12.—Chemical Composition of Ladino Clover and Alfalfa Leaves During Several Months of the Year

Location	Year	Month	Number of samples	N	Protein	P	K	Ca	Mg
				pct.	pct.	pct.	pct.	pct.	pct.
Strip Mine	1948	May	..	....	....	...	....	....	...
Strip Mine	1949	May	4	3.69	23.1	.27	2.34	1.82	.68
Univ. of Ill.[a]	1948	May	2	4.44	27.8	.31	2.09	1.68	.47
Strip Mine	1948	June	..	....	....	...	....	....	...
Strip Mine	1949	June	4	3.03	18.9	.23	2.05	1.60	.60
Univ. of Ill.[a]	1948	June	2	3.56	22.3	.27	1.95	1.45	.45
Strip Mine	1948	July	2	2.79	17.4	.25	1.60	1.74	.59
Strip Mine	1949	July	3	2.93	18.3	.24	2.17	1.47	.54
Univ. of Ill.[a]	1948	July	2	3.44	21.5	.26	1.90	1.56	.57
Strip Mine	1948	August	4	2.80	17.5	.21	1.29	1.57	.56
Strip Mine	1949	August	1	3.68	23.0	.31	2.28	.95	.50
Univ. of Ill.[a]	1948	August	2	3.17	19.8	.24	1.88	1.41	.51
Strip Mine	1948	September	3	2.48	15.5	.22	1.12	1.30	.56
Strip Mine	1949	September	4	3.34	20.9	.24	2.22	1.07	.52
Univ. of Ill.[a]	1948	September	2	3.67	22.9	.27	1.93	1.55	.50
Strip Mine	1948	October	4	3.21	20.1	.24	1.83	1.53	.48
Strip Mine	1949	October	3	3.95	24.7	.24	2.51	1.22	.47
Univ. of Ill.[a]	1948	October	1	3.72	23.2	.23	2.10	1.40	.48
Strip Mine	1948	Average	13	2.85	17.8	.23	1.46	1.42	.49
Strip Mine	1949	Average	19	3.27	20.4	.24	2.18	1.46	.57
Univ. of Ill.[a]	1946-48	Average	50	3.56	22.2	.31	2.24	1.61	.48
Alfalfa leaves - 1948 [a]									
		June	2	4.35	27.2	.33	1.94	2.52	.48
		July	1	4.48	28.0	.29	2.51	1.82	.33
		August	2	3.90	24.4	.20	1.94	1.88	.51
		November	2	3.84	24.0	.23	1.83	2.00	.49
	Average	leaf	3 570 lb/A	4.10	25.6	.26	1.99	2.09	.45
	Average	stem	4 020 lb/A	2.00	12.5	.18	2.15	.83	.31

[a] Snider, H. J. Unpublished data.

Table 13.--Chemical Composition of Three Grass Species Growing on Strip-Mined Lands at Six Different Times of the Year, 1949

Month and crop	Number of samples	N	Protein	P	K	Ca	Mg	Mn	Si
		pct.	pct.	pct.	pct.	pct.	pct.	pct.	pct.
May (Early)									
Bromegrass	2	2.60	16.3	.21	2.75	.45	.29	.0135	2.40
Orchard grass	3	2.19	13.7	.25	2.92	.23	.24	.0114	1.62
Alta fescue	3	1.92	12.0	.22	2.57	.27	.36	.0113	2.38
May (Late)									
Bromegrass	0	....	....	...	....	...	...	.....	....
Orchard grass	2	1.52	9.5	.26	2.40	.30	.25	.0073	2.09
Alta fescue	1	1.48	9.3	.17	1.85	.30	.35	.0070	1.54
June									
Bromegrass	4	1.40	8.8	.15	2.36	.40	.21	.0096	1.46
Orchard grass	4	1.44	9.0	.23	2.32	.56	.33	.0203	2.47
Alta fescue	3	1.17	7.3	.21	2.04	.36	.28	.0117	3.06
July									
Bromegrass	3	1.92	12.0	.24	2.36	.47	.26	.0112	2.07
Orchard grass	3	1.98	12.4	.28	2.71	.70	.45	.0117	2.42
Alta fescue	4	1.91	11.9	.28	1.91	.66	.52	.0127	3.01
September									
Bromegrass	2	2.28	14.3	.26	2.04	.71	.39	.0205	3.03
Orchard grass	3	1.64	10.3	.30	2.02	.63	.44	.0200	3.65
Alta fescue	4	2.04	12.8	.22	2.28	.38	.34	.0119	2.61
October									
Bromegrass	2	1.66	10.4	.18	1.60	.99	.50	.0335	4.15
Orchard grass	3	2.20	13.8	.35	2.37	.62	.38	.0140	3.32
Alta fescue	4	1.98	12.4	.21	2.53	.58	.37	.0124	2.91

Two alfalfa and two sweet clover plants growing on strip-mine land showing top and root growth. The two plants to the left are alfalfa plants. The long taproot of the left plant was over 4 feet long, while the other root shows more branching. The sweet clover plants to the right show a less extensive root system. However, some sweet clover plants have been dug with taproots also over 4 feet long. (Fig. 4)

six legume species is listed in Table 14. The plants were in the full bloom stage except for the first-year sweet clover which was dug in October. The nitrogen content of the roots is generally lower than the tops except for the first-year sweet clover. The calcium content of the roots is from 4 to 7 times lower than the calcium content of the tops.

Animal Gains as a Method of Measuring Yield and Quality:

This is the third year during which steers have grazed on strip-mine pastures and their gains compared with gains made by steers that grazed on undisturbed land in bluegrass. During the 1948 and 1949 seasons the University of Illinois, Animal Science Department, furnished the steers used in the tests. In 1950 the steers used were owned by Mr. Byron Somers, Canton, Illinois, Fulton county, on whose farm the tests were made.

Twenty head of good to high good steers were selected from a drove of cattle which had been wintered on legume hay, corn silage, and some concentrate. On May 5 the steers were gate sorted into two lots. Ten steers were grazed on strip-mined lands, while the same number were run on a bluegrass pasture as a check or control group. Both pastures were the same as those used in 1948 and 1949 in the Fulton county tests.

The steers were kept on the respective pastures until November 7, a total of 186 days. After that date the two lots were run together on an alfalfa, Ladino and bromegrass pasture and started on a light feed of corn. On November 20, after they had been on feed for 13 days, 17 steers were weighed individually. As will be noted in Table 15, 8 steers of Lot 1 and 9 steers of Lot 2 were individually weighed instead of 10 in each lot. When experimental cattle are grazed with other cattle it is difficult to separate and process the test steers, even though the steers were branded. Individual weighing is also a problem particularly if the corral and scale are not

Table 14.--Comparison of the Chemical Composition of the Top and Root Material of Six Species, 1949

Species	Number of samples	Part of plant	N	Protein	P	K	Ca	Mg	Yield ratio root to tops
			pct.	pct.	pct.	pct.	pct.	pct.	
Alfalfa	7	Tops	2.62	16.4	.19	1.60	1.41	.42	1:2.41
		Roots	2.04	12.8	.20	1.07	.34	.22	
Sweet clover 1st year (Oct.)	2	Tops	2.23	13.9	.19	1.05	.63	.42	1:0.97
		Roots	3.43	21.4	.31	.90	.10	.28	
Sweet clover 2nd year (Bloom)	8	Tops	2.41	15.1	.19	1.70	1.11	.54	1:5.77
		Roots	1.39	8.7	.19	1.88	.17	.59	
Red clover	3	Tops	2.62	16.4	.15	1.74	1.32	.55	No data
		Roots	1.99	12.4	.15	1.26	.25	.52	
Alsike	2	Tops	2.29	14.3	.13	1.85	1.00	.59	No data
		Roots	2.19	13.7	.13	1.23	.19	.75	
Birdsfoot trefoil	2	Tops	2.59	16.2	.22	1.30	1.58	.68	No data
		Roots	2.63	16.4	.26	1.14	.21	.29	
Ladino	1	Tops	2.96	18.5	.22	1.95	1.55	.66	No data
		Roots	2.30	14.4	.24	1.32	.20	.43	

Table 15.--Individual Weights of Steers Pastured in 1950

Tattoo	Weight May 5 lb.	Weight[a] Nov. 20 lb.	Gain on pasture lb.	Average daily gain lb.
Lot 1 -- Spoil bank pastures - Fulton county				
78	790	1 110	320	1.61
80	850	1 150	300	1.51
82	810	1 200	390	1.96
84	850	1 200	350	1.76
86	810	.....	...	....
88	700	.....	...	....
90	930	1 130	200	1.01
92	830	1 110	280	1.41
94	850	1 170	320	1.61
96	790	1 120	330	1.66
Averages	821	1 149	311	1.56
Lot 2 -- Undisturbed bluegrass pasture Fulton county				
79	860	1 110	250	1.26
81	800	1 030	230	1.16
83	870	1 140	270	1.36
85	820	1 040	220	1.11
87	740	940	200	1.01
89	850	1 110	260	1.31
91	790	990	200	1.01
93	760	.....	...	....
94	790	1 060	270	1.36
94	888	1 070	190	.95
Averages	816	1 054	232	1.17

a/ Weights after 186 days of pasture plus 13 days on feed (corn) and alfalfa, Ladino, brome field pasture.

especially equipped. Two steers were acidentally let out at the same time and were mixed with the herd again. It was not practical to resort and re-inspect the whole herd to get the individual weights of the two steers. These are the reasons why only 17 steers were weighed individually. The results, in terms of animal gains, for the 199 day period were as follows:

	Av. wt. May 5 lb.	Av. wt. Nov. 20 lb.	Av. total gain lb.	Av. daily gain lb.
Lot 1, test steers 1/	838	1 149	311	1.56
Lot 2, control steers 2/	822	1 054	232	1.17

1/ Average initial and final weights of 8 steers.

2/ Average initial and final weights of 9 steers.

Table 15 gives the individual weights of each steer on May 5 and on November 20 and shows the difference in individual gains. For the 17 steers on which individual weights were taken the total gain varied from a high of 390 pounds to a low of 190 pounds per head. A statistical analysis of the results shows that the difference in gains made by the two lots is highly significant. The 1948 and 1949 results showed no significant difference in the gains made by the two groups.

Lot weights of both groups of steers were obtained on August 14. Lot 1 had gained an average of 151 pounds while Lot 2 had gained an average of 144 pounds per head. The average daily gains for the 101 days that they had been on pasture were 1.50 and 1.44 pounds respectively. Unfortunately neither lot of steers was weighed when it was removed from its experimental pasture on November 7 and turned onto a field of alfalfa-Ladino, bromegrass pasture where grain feeding was begun. However, all steers, except 3, were weighed individually November 20, but these weights were in all probability materially larger than those which would have been obtained 13 days earlier before grain feeding had begun. If it is assumed that the steers gained

30 pounds each during the 13-day feeding period, the pasture gains for Lot 1 would be 281.5 pounds for 186 days. Of this gain 151 pounds were made the first 101 days for an average of 1.50 pounds per day and 147 pounds were made in the last 85 days for an average of 1.73 pounds per day. The averages for the first 101-day period are for 10 steers while the averages for the last period are for 8 steers. Using the same assumptions for Lot 2, a gain of 208 pounds in 186 days is obtained, 144 pounds of which were made in the first 101 days for an average of 1.43 pounds per day, while only 64 pounds were made in the last 85 days for an average of only 0.75 pound per day.

These results show that during the last half of the grazing period the gains made on the strip-mine pasture were very much higher than those made on the bluegrass pasture. The quality of forage on the strip-mine pasture was excellent throughout the year. The growth of legumes during the late summer and early fall was especially outstanding.

A summary of the results obtained during the three grazing seasons in terms of average daily gains is as follows:

	Av. daily gain 1948	Av. daily gain 1949	Av. daily gain 1950	Three-year Av. daily gain 1948-1950
	lb.	lb.	lb.	lb.
Lot 1, strip-mine pasture	1.19	0.98	1.56	1.24
Lot 2, farm-land pasture	1.29	1.10	1.17	1.19

The three-year average daily gain for the Lot 1 steers was 1.24 pounds compared with 1.19 pounds for the Lot 2 steers. The average number of days on pasture was 176 days. A statistical analysis of the results obtained over the three-year period shows that the difference in gains made by the two lots is not significant.

In 1950 it was possible also to obtain the gains made by several herds of livestock grazing on strip-mined lands. One of these was a herd of

Livestock on full feed of concentrate while on strip-mined pastures in Fulton county.
(Fig. 5)

95 yearling steers owned by Mr. Byron Somers of Fulton county. The average weight of these 95 steers was approximately 480 pounds when turned on the strip-mined pasture on May 5, 1950. Their average weight on December 1, 1950, was 789 pounds. These steers grazed on the pastures for 210 days and had gained an average of 309 pounds per steer. They made an average daily gain of 1.47 pounds, whereas the 10 test steers on similar pasture made an average daily gain of 1.56 pounds during practically the same period.

The Meadowlark Farms, Inc. pastured a total of 95 steers and 33 heifers on strip-mined lands in Fulton county in 1950. The 95 steers were turned on pasture on May 1 at an approximate weight of 500 pounds. They were taken off on October 11, at which time 43 of the more common steers were sold at an average weight of 732 pounds. This represents a gain of 232 pounds in 165 days of grazing or an average daily gain of 1.4 pounds. The rest of the steers were placed on full feed and have not been marketed as yet.

The 33 heifers also were placed on the strip-mine pastures on May 1 at an average weight of about 450 pounds. They were taken off on September 17 when 26 head were sold at an average weight of 648 pounds. This represents a gain of 198 pounds in 138 days for an average daily gain of 1.4 pounds.

ECONOMIC INTERPRETATIONS:

Methods, Costs, and Feasibility of Forage Species Establishment:

The methods of seeding the mined areas in the past have been hand seeding, tractor mounted power seeder, and air seeding by airplane and helicopter. There were no air seedings of strip-mined land made in Illinois in 1950. The length of time required to seed the areas depends to a great extent on the species seeded. The seed of some of the grass species is very light in weight and bulky and requires more time to seed. It required 357

hours to seed one block of 262 acres by hand seeding or approximately 1 hour and 22 minutes per acre. Another area of 650 acres was hand seeded in 355 hours or approximately 33 minutes per acre. The windmill type of hand seeder has been most successful.

The total cost per acre varied greatly depending on the kind of seed or mixture used, the seeding rate per acre, as well as the labor involved. During the 1950 season the total costs ranged between $10 to $15 per acre.

Accessibility After Establishment:

In developing a mined area for pasture, accessibility throughout the area is of prime importance. Those who have had experience in managing livestock on strip-mined pasture are in accord with the recommendations and need for adequate roadways. The term adequate is extremely relative and usually too few roadways are made rather than too many.

Some companies in developing an area for pasture have been knocking off the tops of all ridges to a width of from 12 to 16 feet before seeding. On one 305 acre area, using a D-8 dozer, it required 356 hours to top all ridges to an approximate average top width of 14 feet. Based upon a competent mining engineering source the total cost of operating a D-8 dozer under 1950 prevailing costs, mine labor rates, insurance, depreciation, etc., was approximately $7.35 per hour. At the rate of $7.35 per hour the cost to strike-off all the ridges on this 305 acre area would be approximately $8.60 per acre. If the strike-off work can be done for a reasonable amount the benefits derived will more than repay the costs. The area is readily accessible to seed either by hand or with tractor mounted seeders, roadways are already made, the management and control of livestock are made easier, and the scenery or sky line has been improved.

Financial Returns:

The factor that will determine the extent of development and future

View of a grading project for a fence line and roadway into a large mined area. Adequate roadways and fencing into smaller pasture fields for rotational grazing are essential for efficient livestock management. (Fig. 6)

use of mined areas is the financial returns realized from the use of strip-mined pasture lands or on leveled areas from the product produced. Financial returns on the pastures are dependent upon the gains made by livestock and the price of the livestock, and on the leveled areas on the yield and price of the produce raised.

For example from the pasture lands, if over a 176 day pasture season each steer gained on the average 1.25 pounds per day, then 220 pounds of beef would be produced per steer. Also assuming, and there is some basis for the assumption, that the carrying capacity of a good strip-mined pasture is 2 acres per head or animal unit per year, then each acre of the pasture has produced 110 pounds of beef per year. If the beef were sold at 28 cents per pound, the gross value would be $30.80 per acre.

What return can be expected from a leveled area? If such an area were growing alfalfa and were cut for hay, assuming a yield of 3.5 tons of alfalfa hay per acre (average yield reported in Table 7) and a value of $20 per ton, the gross returns would be $70 per acre. The actual yield of 1 acre of alfalfa hay in 1950 was 186 bales or 12,620 pounds or 6.3 tons per acre. At $20 per ton the gross returns on this acre of leveled land in 1950 were $126.

One way of utilizing a strip-mined land is by organizing the mined and unmined land into farm units. By following a planned, long-range program, the costs and problems of establishing a profitable farm unit, the nucleus of which is the strip-mined land, can be greatly reduced. To accomplish this, two things need to be done: (1)The lands that do not contain mineable coal, and which make up a part of every mine property, must be improved and maintained as soon as control is acquired, and (2) the mined land must be developed progressively each year and utilized as soon as it is ready to produce.

The most concentrated and continued use of these lands will be made in this way, -- by incorporating the mined land with surrounding farm land into a well organized farm unit.

This principle has been put into effect in a number of instances. According to the Illinois Coal Strippers Association there are 16 units in operation or under planning and development at this time. These 16 units involve approximately 9,000 acres of mined land, approximately 5,000 acres of which were in actual use during 1950 and most of the remaining 4,000 acres will be used during 1951. The strip-mined areas in these units vary in size from 80 to 2,500 acres. The units also vary widely from well-planned, highly organized, operating units and well planned units not yet in full operation to areas that are used only for grazing purposes.

An example of some of the steps that are taken to organize and evaluate such a farm unit is presented. A plan similar to this can be drawn up for the utilization of most of the strip-mined lands in Illinois.

A FARM ORGANIZATION AND OPERATIONAL PLAN FOR LAND-USE OF A TYPICAL STRIP-MINE AREA PUT INTO OPERATION IN 1950:

Description of Soil and Land Capabilities Classification:

This proposed plan is for 743.5 acres of land that has been classified as follows: 265 acres of tillable crop land, 206.5 acres of nontillable land, and 272 acres of strip-mined land. The land use capabilities are as follows:

Class II	179 A.	Clinton and Berwick s.l.
Class III	56	Rolling Clinton phase
Bottom	30	Huntsville-like s.l.
Class VI	206.5	Hickory Complex
Spoils	272	Seeded March, 1950

The Class II land (on map) can be cultivated safely with easily applied special practices. The predominant soil types are Clinton silt loam and Berwick loam, with a productive rating of 5 to 6. The rotation sug-

gested is a 2-1-2, or more specific, corn, corn, oats or other small grain, hay, hay. The conservation practices needed are adequate grass waterways and the application of limestone and phosphate and the growing of legumes.

Approximately 56 acres of tillable land are Class III land. The dominant soil types are probably strongly sloping Clinton silt loam or less severe Hickory complex. When the land is cultivated more intensive conservation practices are necessary. Grass waterways, contour farming, and a less severe rotation are recommended. The suggested rotation is 1-1-4, or corn, oats, hay, hay, hay, hay. The remaining 30 acres is bottomland. This land is subject to overflow, but is potentially productive. The rotation suggested is corn, beans, with a rye cover crop.

The nontillable land, Class VI, is land that is not suitable for cultivated crops but is suitable for pasture. This land should be renovated for best pasture production. The 272 acres of strip-mined land were thoroughly sampled and the soil tested. Ninety-five samples were taken and the average pH was 7.47, the average available phosphorus was 145.7 pounds and the average available potassium was 153.6 pounds, excellent for potential pasture production. This area was seeded during March, 1950, with a mixture of alfalfa, sweet clover, Mammoth clover, Ladino clover, orchard grass, and bromegrass at the rate of 20 pounds per acre. These pastures should be ready for use after April 30, 1951. There is a total of 478.5 acres of pastureland.

The land use capabilities map is presented, and shows field arrangement, size of fields, and possible rotations. The proposed land use during a complete rotation cycle is also given.

Investment for Limestone and Phosphate:

The soil of the tillable crop land was sampled and tested for acidity, phosphorus, and potassium. Past history of the fields shows that

little or no limestone or phosphate or manure has been applied the last 8 years. The tests reveal that 3 tons of limestone and 1,000 pounds of rock phosphate are required on all 265 acres. These applications should be made as soon as it fits into the rotation to do so, either before the oats or the beans are seeded.

A summary of the estimates are:

3 T/A. Ls.	@	\$ 3.25/T	\$ 9.75/A.	\$ 2,583.75
1,000 #/A. r.phos.	@	24.00/T	12.00	3,180.00
			Total Cost . . .	\$ 5,763.75

Commercial fertilizers are also recommended (see Field plans) but they are considered to be annual expenditures with no carry-over value.

PROPOSED LAND USE DURING A COMPLETE ROTATION CYCLE

Field No.	Acres	1950	1951	1952	1953	1954	1955
Class II							
1	36	Oats^{H}	Hay	Corn	Corn	Oats^{H}	Hay
2	31)-38 7)	Corn	Oats^{H}	Hay	Corn	Corn	Oats
3	25)-34 9)	Beans	Oats (Lesp.H)	Hay	Hay	Corn	Corn
4	12) 9)-35 14)	Corn	Corn	Oats^{H}	Hay	Hay	Corn
5	36	Oats (Lesp.H)	Corn	Corn	Oats	Hay	Hay
	179 Acres						
Class III							
A	11	Corn	Oats^{H}	Hay	Hay	Corn	Oats^{H}
B_1	8	Beans	Oats^{H}	Hay	Hay	Hay	Corn
B_2	7	Beans	Oats^{H}	Hay	Hay	Hay	Hay
C_1	10	Oats(S.C)	Corn	Oats^{H}	Hay	Hay	Hay
C_2	10	Oats^{H}	Hay	Corn	Oats^{H}	Hay	Hay
C_3	10	Oats^{H}	Hay	Hay	Corn	Oats^{H}	Hay
	56 Acres						
Bottomland							
I	14	Beans(Cov)	Corn	Beans(Cov)	Corn	Beans(Cov)	Corn
II	16	Corn	Beans(Cov)	Corn	Beans(Cov)	Corn	Beans(Cov)
	30 Acres						
	265 Acres of Tillable Crop Land.						

Noncrop land 206.5 Acres Permanent Place Land Pasture.

Spoils 272 Acres Permanent Spoils Pasture, Seeded March, 1950.

Acres of Corn	100	95	98	98	99	91
Acres of Oats	102	98	45	46	46	49
Acres of Hay	(36)(Les)	56 (34)	108	105	106	109
Acres of Beans	63	16	14	16	14	16
Acres of Pasture	478.5	478.5	478.5	478.5	478.5	478.5

Fence:

The fence lines are shown on the land use map by the ---- lines. The area around the farm headquarters, northwest quarter of Section 26, will require approximately 672 rods. Woven wire, plus 2 strands of 4-pt. barb wire, and posts approximately 1 rod apart, are recommended for this area. The total cost of the material and erection is estimated to be $2.50 per rod. For the remainder of the fence, 4 strands of 4-pt. barb wire and posts 1 rod apart are suggested. The total cost of this type of construction is estimated to be $1.50 per rod. The following breakdown for the fence is:

1.	Northeast quarter, north of haulage road	380 rod
2.	Large block of spoils	984 rod
3.	West block of spoils	620 rod
4.	Hornback area	300 rod
		2 284 rod
5.	Northwest quarter, woven wire	672 rod

Grass Waterways:

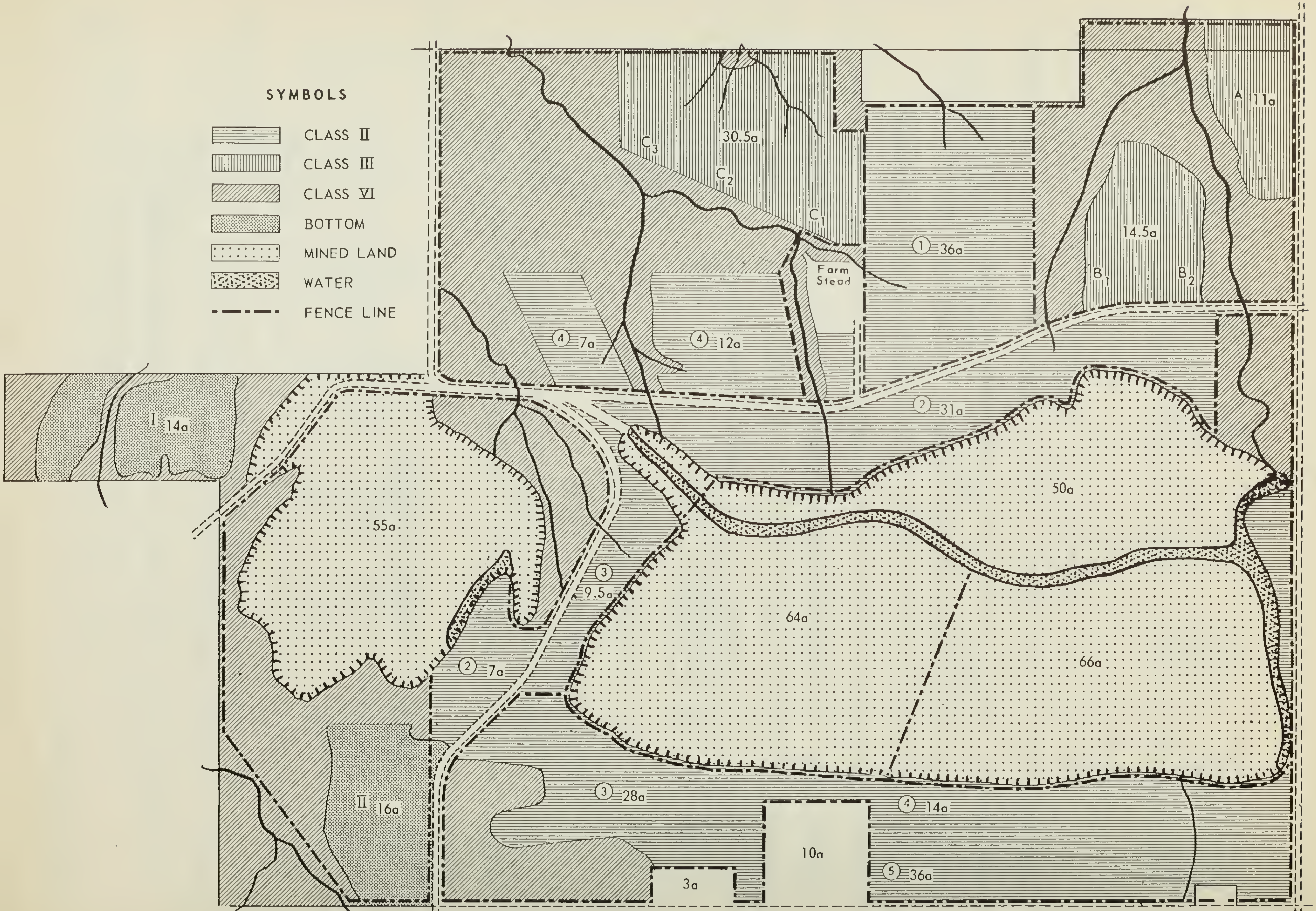
No added cost is estimated in the installation of the waterways because in most instances this can be accomplished during the time the hay or meadow occupies the land.

Acreages and Probable Production:

The estimated yields that are expected on this farm are based on yields predicted in Illinois B-522 "How Productive are Illinois Soils." For the Clinton silt loam soil type under good soil management the following yields can be expected: Corn--64 bushels; soybeans--24 bushels; oats--37 bushels; grass-legume hay--2.2 tons. For the first two years, 1950 and 1951, lower yields have been used and is reflected in the Crops income.

The acreages and probable production are as follows, 1952 being the year summarized:

Land Capability Classification and Field Arrangement Map



Scale: 6-7/8" = 1 Mile

Crop	Acres	Estimated production per acre	Total
Corn	98	55-67 bu.	6 446 bu.
Oats	45	35 bu.	1 575 bu.
Soybeans	14	24 bu.	336 bu.
Hay-baled	30	2.2 T.	124 T.1/
Grass silage	781/	5.0 T.	390 T.
Permanent Pasture			
Place land	206.5	2 1/2 acres per animal unit.	200 Head of steers
Spoils	272		
	743.5		

1/ The second cutting of area used for grass silage is cut for hay.

Under normal production the carrying capacity of the spoils pasture has been estimated to be from 2 to 4 acres per animal unit. For this area the carrying capacity is estimated to be one animal unit per 2 1/2 acres. At this rate the total pasture area should support approximately 200 head of yearling steers.

Up to this point the cropping system, the land use possibilities and the cost of a permanent fertility program have been expounded. The next step is to fit the livestock program to the cropping system and to estimate income and expenditures, and then the rate of earning of the capital invested.

Livestock Enterprise:

As stated previously the farm has a total of 478 acres of permanent pasture of which 272 acres is mined land. From past experiences with spoil bank pastures in Illinois the carrying capacity has been estimated at from 2 to 4 acres per animal unit. The carrying capacity is estimated at 2 1/2 acres per animal unit since these are some of the better spoils in Illinois. At this rate of stocking just under 200 head of steers can be handled.

High good to choice yearling steers are recommended because this grade can best utilize the large amounts of pasture and roughage that are produced.

Cattle feeding risks can be reduced by buying and selling wisely. From a study of seasonal price movements based on averages over a period of years, it is shown that the seasonal low for good feeder steers is in the fall from August to November. The seasonal high price for good fat steers the past years has been in the fall from August to October with September being the high month. Prices in a particular year may vary from the seasonal price due to different factors that may influence prices in any particular year. Thus, vary buying time and selling time with the present outlook.

In starting this program (1950) it is recommended that about 70 head (2 carload) of good yearling steers be purchased in August or September, 1950, weighing about 550 pounds. In the fall of 1951, 200 steers should be purchased. The steers can utilize wastes such as cornstalks, bean fields, meadow aftermath, spoil pastures, etc., until approximately December 1. Up to this time the steers have been owned about 90 days and should weigh between 600 to 625 pounds.

The wintering period is estimated to last until April 15, a period of about 140 days. Stocker cattle should be wintered sufficiently well to obtain normal rate of growth with little or no improvement in condition. This objective is achieved when approximately 1.0 pound gain per day is made by yearling steers. The wintering ration recommended is:

Grass silage	28 pounds for 140 days	200 head	392 T.
Mixed hay and straw	6 pounds for 140 days	200 head	84 T.

The summer pasture is estimated to begin April 15 to 20 at which time the steers go on the spoil bank pasture. Good rotation management is necessary to keep the pastures producing well and steers to gain adequately. The steers will weigh about 725 pounds on April 15, and estimating the following monthly gains while on pasture: April, 10 pounds; May, 80 pounds; and June, 60 pounds; a total of 150 pounds. The steers will weigh 850 to 875

pounds by July 1. At this time they are to begin the 90 to 120 day fattening period. The feeding for the first 30 days at least can be started while still on pasture. From results obtained from grazing experiments conducted in 1948 and 1949 the steers have gained 1 pound per day for a 180 day pasture season.

Good 2-year-old steers should make an average daily gain of 2.5 pounds per day while on feed. At this rate of gain they should weigh between 1,050 to 1,100 pounds by October 1. In an average year at this rate 200 pounds of steers will weigh a total of 210,000 pounds.

The fattening ration suggested is:

30 days on pasture;	13 pounds corn-and-cob meal	31 days	200 head	1,151 bu.
60 days in dry lot;	13.5 pounds shelled corn	61 days	200 head	2,941 bu.
	6.75 pounds mixed hay	61 days	200 head	41.2 T.
	1 pound protein sup.	61 days	200 head	6.1 T.

The total amount and cost of feed utilized is:

			January 1950 Estimate	January 1951 Estimate	
Winter period	Grass silage	392 T. @ $6.00/T	$ 2 352.00	$ 7.50	$ 2 940.00
	Hay and straw	84 T. @ 12.00/T.	1 008.00	20.00	1 680.00
Fattening period	Corn	4 092 bu. @ .90	3 683.00	1.75	7 161.00
	Hay	41.2 T. @ 12.00/T.	500.00	20.00	824.00
	Protein	6.1 T. @ 80.00/T.	488.00	90.00	549.00
			$ 8 031.00		$13 154.00

Hogs Enterprise:

Hogs following full-fed steers can be expected to make 2 pounds gain per bushel of corn while the steers are fed on legume pasture and 1.5 pounds per bushel while on dry lot. The ratio of hogs to cattle, no extra corn fed to hogs is 1.3. At this rate approximately 66 hogs should follow the 200 steers. For simplicity in computation the 66 hogs are purchased weighing 110 pounds at 15 cents per pound. The gains expected from the hogs:

31 days	1,150 bu. corn fed	2 lb. gain per bushel	2,302 lb.	or 35 lb/head
61 days	2,941 bu. corn fed	1.5 lb. gain per bushel	4,411 lb.	or 67 lb/head

A total of 6,713 pounds of pork is produced by this means at no extra cost for

feed.

A summary of livestock numbers and feed requirement, crop production and disposal is as follows:

Livestock	Corn bu.	Oats bu.	Mixed hay	Grass silage	Protein supplement	Beans bu.
200 yearling stockers	0	0	84 T.	392 T.	0	0
200 2-year-olds	4 092	0	41.2 T.	0	6.1 T.	0
66 hogs	Follow cattle no extra feed.					
Total use	4 092	0	125	392	6.1	0
Production	6 446	1 575	124	390	0	336
For sale	2 354	1 575		0		336
Purchase					6.1	

The seasonal high price for grain is as follows: Corn--July; oats--April; soybeans--May.

Farmstead Arrangement:

In planning the farmstead an arrangement should be considered that provides adequate and economical units of construction and land use for maximum efficiency, beauty and enjoyment. The arrangement of the buildings and lots and the type of building construction determine to a considerable degree the efficiency of doing the work at the farmstead as well as the attractiveness of the home.

Building Requirements:

The values here given are very rough estimates. The physical requirements are those needed for adequate production.

Barn (30 x 50 present now)	$ 2 000.00
Shed around barn	2 000.00
Paved lot	2 500.00
Feed bunks	300.00
Crib (8' - 12,000 cu.ft., 4,200 bu.)	2 200.00
Silo	1 800.00
Machine shed	1 200.00
House	2 500.00
Total value	$14 500.00

The center of the farmstead is the barn and crib area. The space needed per animal is 25 sq. ft. of shed space plus 35 sq. ft. of paved lot

area. Thus, for 200 head of cattle 5,000 sq. ft. of shed space and 7,000 sq. ft. of paved lot is needed. By building a shed around the present barn adequate shed space can be provided. The center of the barn can be used for baled hay. The area needed for 125 ton of hay is 20,000 cu. ft. The paved lot should be 5 inches thick and reinforced. The estimated cost is $2,500. Approximately 14, 3' x 16' feeding bunks with access to both sides and approximately 260 linear feet of hay feeding space is required. A masonry silo for the grass silage is recommended. The reason for grass silage is this. Rainy weather at first cutting time usually results in poor quality first cutting hay. This can be partially solved by using as much of the first cutting as needed for grass silage. Just under 400 tons can be fed.

Approximately 12 gallons of water per head is needed daily. This needs to be provided only during wintering and fattening periods. There is adequate water in the spoil bank pastures. Cattle on pasture require approximately 2.5 pounds of salt per month, and 100 pounds in dry lot. Block salt is the most convenient form to use. From 20 to 22 pounds of salt per animal are needed or about 2 tons of block salt per cycle.

Estimated Prices:

This plan was prepared for action in the spring of 1950. The prices used were conservative estimates of what prices might be in a declining price market. Actually as a result of the Korean war and the military preparedness programs, prices have increased. By using the physical units given and the current prices for each product the financial statement can be adjusted to any conditions.

The prices used in the estimate made in January, 1950, for the crops are as follows: Corn, 90 cents; oats, 50 cents; soybeans $1.90 per bushel; baled hay $12 per ton and grass silage $6 per ton. The current prices for

the same crops in January, 1951, were as follows: Corn, $1.75; oats, 95 cents; soybeans $3.20 per bushel; hay $20 per ton and grass silage $7.50 per ton. Using the 1950 estimate the total crop receipts for 1952 would be $11,055 and using the 1951 current price the crop receipts would be $29,257.00.

Similarly the cost of the feed for livestock based on 1950 estimates would be $3,360 for the wintering period plus $4,665 for the fattening period making an estimated total of approximately $8,031 compared to a total of $13,154 by using the 1951 current price.

The estimate made in 1950 as to what the price of good grade steers would be in 1952 was 20 cents per pound. Thus, it was estimated that in the fall of 1951, 200 steers weighing 550 pounds each should be purchased at an estimated total cost of $22,000. Again using the January, 1951 current price of approximately 30 cents per pound the total cost of these steers would be $33,000.

According to Snapp (2) profits from cattle feeding usually result from selling the original weight of the steer for more than it cost. The algebraic difference between the sale and cost prices per hundredweight is referred to as "the margin." The factors that determine the amount of margin that must be had to cover all costs are: (1) The initial weight of the cattle, (2) the cost per hundredweight of the cattle, (3) the cost of the gains made, and (4) the amount of gains made.

By using the large amounts of grasses and legumes produced on strip-mine farms it is possible to keep the cost of livestock gains relatively low. When light-weight, high-quality cattle are used and the cost of the gains kept relatively low a profit can be made even when using a zero price margin spread. In this estimate the purchase price is used as the selling price, or a zero margin price spread is used.

The January, 1950 estimate of the price of cattle in 1952 was 20 cents per pound. The current January, 1951 price is approximately 30 cents per pound. Likewise the 1950 estimate of hogs selling in 1952 was 15 cents per pound but the current 1951 price for hogs is approximately 20 cents per pound.

Expenditures, Receipts, Net Income, Rate Earned on Capital Investment:

The differences in prices are reflected in the two summary sheets presented. The first is based on the estimate made January, 1950 of what prices were to be in the following three years. The second is based on the current January, 1951 prices. Using the 1950 estimates the net returns for capital and management for 1952 are estimated to be about $9,609 but using the current 1951 prices as listed the net returns for capital and management are $20,204. This plan shows that even in a period of lower prices it should be profitable to utilize the strip-mined lands.

Using the Twenty-fourth Farm Bureau Farm Management report for farms averaging 340-499 acres on which livestock is the principal enterprise, the Strip-Mine Farm, for the year 1952, can be rated or compared in the following ways:

	Strip-Mine Farm	F.B.F.M. (Soil Rating 3.1)
1. Rate earned on investment	12.9%	11.99%
2. Net Mgt. returns per acre	$ 10.03	$ 16.80
3. Capital invested per acre	100.41	240.21
4. Total in-puts per acre	33.08	101.90
5. Total returns per acre	43.11	118.70

Using the current January, 1951 prices as shown in the second summary sheet the comparisons are as follows:

1. Rate earned on investment	22.2%	11.99%
2. Net Mgt. returns per acre	$ 24.29	$ 28.83
3. Capital invested per acre	122.58	240.21
4. Total in-puts per acre	43.77	101.90
5. Total returns per acre	68.06	118.70

Estimate Made January, 1950 of What Prices May Be,
in a Declining Price Period, for the Following Three Years
Summary Sheet Strip-Mine Farm (743.5 Acres)

	Items	Value	Annual charge-off rate	1950	1951	1952
1.	Land improvement	$ 5 765.00	10%	$ 577	$ 577	$ 577
2.	Spoil devp. (seed & labor)	3 285.00	10%	329	329	329
3.	Access roads, etc. (bldzr)	5 000.00	12 1/2%	625	625	625
4.	Fence	5 106.00	5%	256	256	256
5.	Buildings	14 500.00	4%	580	580	580
6.	Machinery & equipment	9 300.00	12 1/2%	1 165	1 165	1 165
7.	Int. on capital Invest.	42 956.00	5%	2 148	2 148	2 148
8.	Livestock - steers (Inv))		Included to show	0	10 867(Inv)	26 000 (Inv)
	steers pur. Aug.)		volume; not in-	8 855	22 000	22 000
	hogs pur.)		cluded in totals	0	345	1 089
9.	Interest on livestock		5%	168	603	1 196
10.	Feed for livestock			285	4 207	8 031
11.	Interest on livestock feed		5%	0	210	402
12.	Labor - operator			2 200	2 200	2 200
	hired			1 500	1 500	1 500
13.	Machinery & equip., repairs & fuel			2 500	2 500	2 500
14.	Seed crop-cultivated			562	384	298
	hay			534	458	279
15.	Fertilizer			960	834	135
16.	Insurance on livestock			200	500	500
	Insurance on buildings			70	70	70
17.	Taxes @ $1.75/A			1 303	1 303	1 303
18.	Miscellaneous			500	500	500
	TOTAL INPUTS			$17 462	$20 949	$24 594

RETURNS

		1950	1951	1952
Crop		11 322	9 683	11 055
Livestock - steer sales)	Included to show	0	16 905	42 000
inventory)	volume; not in-	10 867	26 000	26 000
hogs)	cluded in totals	0	818	2 089
Livestock returns		0	10 511	21 000
TOTAL RETURNS		$11 322	$20 194	$32 055
Net returns for management		- 3 128	- 755	7 461
Plus capital charge		2 148	2 148	2 148
NET RETURNS FOR CAPITAL AND MANAGEMENT		- 980	+1 393	+9 609

The capital investments for this farm are:

Land improvements	$ 5 765
Spoils development	3 285
Access roads, etc. (development)	5 000
Fence	5 106
Buildings	14 500
Machinery	9 300
Livestock	23 089
Feed and seed	8 608
TOTAL CAPITAL INVESTMENT.	$74,653

Estimate Using Current January, 1951 Prices for 1951 and 1952
Summary Sheet Strip-Mine Farm (743.5 Acres)

	Items	Value	Annual charge-off rate	1951	1952
1.	Land improvement	$ 5 765.00	10%	$ 577	$ 577
2.	Spoil devp. (seed, etc.)	3 285.00	10%	329	329
3.	Access roads	5 000.00	12 1/2%	625	625
4.	Fence	5 106.00	5%	256	256
5.	Buildings	14 500.00	4%	580	580
6.	Machinery & equipment	9 300.00	12 1/2%	1 165	1 165
7.	Int. on capital investment	42 956.00	5%	2 148	2 148
8.	Livestock - steers (Inv))	Included to show		12 250	39 000
	steers pur. Aug.)	volume; not in-		33 000	33 000
	hogs pur.)	cluded in totals		460	1 452
9.	Interest on livestock		5%	959	1 806
10.	Feed for livestock			6 287	13 154
11.	Interest on livestock feed		5%	314	658
12.	Labor - operator			2 200	2 200
	hired			1 500	1 500
13.	Machinery & equip., repairs & fuel			2 500	2 500
14.	Seed crop-cultivated			384	384
	hay			458	458
15.	Fertilizer			834	834
16.	Insurance on livestock			500	500
	Insurance on buildings			70	70
17.	Taxes @ $1.75/A			1 303	1 303
18.	Miscellaneous			1 500	1 500
	TOTAL INPUTS.			$32 489	$32 547

RETURNS

		1951	1952
Crop		17 398	19 257
Livestock - steer sales)	Included to show	20 580	63 000
inventory)	volume; not in-	39 000	39 000
hogs)	cluded in totals	1 090	2 798
Livestock returns		13 960	31 346
TOTAL RETURNS		$31 358	$50 603
Net returns for management		- 1 131	+18 056
Plus capital charge		2 148	2 148
NET RETURNS FOR CAPITAL AND MANAGEMENT.		+ 1 017	+20 204

The capital investments for this farm using January, 1951 prices are:

Land improvements	$ 5 765
Spoils development	3 285
Access roads, etc. (development)	5 000
Fence	5 106
Buildings	14 500
Machinery	9 300
Livestock	34 452
Feed and seed	13 731
TOTAL CAPITAL INVESTMENT.	$91 139

There has been no value placed on the land in the above calculations mainly for the reason that the total cost of the land to the company has been entirely amortized in the cost of mining. Any value placed on this land will, of course, reduce the net profits expected. A detailed outline of the grain and livestock program to be followed for the three years, 1950 to 1952, is presented in Appendix A.

A LIST OF REFERENCE MATERIAL THAT IS HELPFUL IN WORKING UP A FARM PLAN INCLUDES THE FOLLOWING:

1. Soil Report for County - Illinois Agricultural Experiment Station.

2. How Productive are the Soils of Central Illinois. Illinois Agricultural Experiment Station Bulletin 522. 1947.

3. A Guide for the Management of Soils, Field Crops, and Pastures in Illinois. Illinois Agricultural Experiment Station and Soil Conservation Service, USDA. January, 1950.

4. Illinois Agricultural Handbook. Extension Service in Agriculture and Home Economics. University of Illinois College of Agriculture. 1949.

5. Planning the Farm Business. University of Illinois College of Agriculture, Extension Service. 1947.

6. Planning the Illinois Farmstead for Efficiency, Health and Enjoyment. Extension Service, University of Illinois College of Agriculture. 1946.

7. Illinois Farm Economics, Extension Service, Department of Agricultural Economics, University of Illinois College of Agriculture. May, 1947.

8. Tenth Annual Report of Feeder Cattle. Illinois Agricultural Experiment Station. August, 1949.

9. Buying Feeder Cattle by Walter J. Wills, Department of Agricultural Economics, University of Illinois College of Agriculture, A.E. 2626. May, 1949.

10. Suggestions for Increasing Labor Efficiency Emergency Farm Labor Program. College of Agriculture, University of Illinois, FL 100. January, 1945.

11. Midwest Farm Handbook, Iowa State College Press. November, 1949.

12. First, Second and Third Annual Reports of Work on a Cooperative Investigation Conducted by University of Illinois, Agricultural Experiment Station and Illinois Coal Strippers Association. 1947, 1948 and 1949.

13. High Quality Forage by Dr. G. Bohstedt, Department of Animal Husbandry, University of Wisconsin.

14. Annual Reports of the Farm Bureau Farm Management Service, Department of Agricultural Economics, University of Illinois, College of Agriculture. Current years.

FUTURE PLANS AND DISCUSSION

Many of the phases of the project that are now in progress will be continued or expanded. These will include seedings of species that have given indication of value and require further study, expansion of spoil type studies, continuation of soil infiltration work, forage yield measurements, animal gains, analysis for chemical composition, etc.

There has been a marked change in the thinking and action programs of member companies in the problem of utilizing the strip-mined lands. It should be repeated that there is no <u>one</u> method of reclamation that is <u>the</u> best or that will solve all the problems. Rather several methods when forcibly put into effect demonstrate that the areas are productive and can be a profitable financial holding.

SUMMARY

Based on soil reaction or pH and available nutrient content the strip-mined lands in Illinois can be classified as being potentially excellent for the production of forage crops. Due to the heterogeneity of the soil material thorough sampling and testing should be done before using any area. In several areas of Illinois the physical and chemical nature of the overburden is such that grading appears to be feasible. Studies on soil structure and on the growth of forage further substantiate this.

Grasses and legumes can be established on most of the strip-mined lands in Illinois. The chemical composition of the forage produced is as high or higher than average in the essential nutrients, protein, phosphorus, calcium and potassium. The three-year average daily gain of steers that grazed the forage growing on strip-mined pastures was 1.24 pounds compared to 1.19

pounds for the control steers that grazed on unmined lands.

The most concentrated and continued use of mined lands can be made by incorporating the mined land with surrounding farm land into a well organized farm unit. Such use is shown to be quite profitable even in a period of lower prices.

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AGRONOMIC LAND USE RESEARCH ON THE MINED AREAS
OF THE STRIPPED COAL LANDS OF ILLINOIS

APPENDIX A

APPENDIX A: DETAILED FIELD AND CROPPING PLAN FOR 3-YEAR PERIOD (1950-52)

1950 FIELD AND CROPPING PLAN

SEE LAND USE MAP FOR FIELD ARRANGEMENT

Fld. (1) 36 Acres — Cost/A

Seed to oats 1 1/2 bu/A @ 70 cents (Clinton oats)		$ 1.05		
Legume-grass seed		7.05		
Alfalfa 6 @ .65	$3.90			
Red Cl. 4 @ .60	2.40			
Tim. 3 @ .25	.75			
Fertilizer 100 lb. 0-20-20 @ 60.00/T		3.00		
		$ 11.10	x 36 -	$ 399.60

Limestone and rock phosphate should be applied before seeding. Cost figured as one lump sum in summary - not figured extra here. If ls. and phosphate is not applied do not seed clover mix.

YIELDS - 35 bu/A expected (unless oats too late)
1260 bu. x 55 cents/bu. - $ 693.00

- -

Fld. (2) 38 Acres

Plant to corn (corn and beans now)

9 lb/A @ 20 cents/lb.	$ 1.80		
Nitrogen (top-dress) 200 lb. Ammonium nitrate per acre - $3.80/cwt.	7.60		
	$ 9.40	x 38A -	$ 357.40

YIELDS - 55 bu/A x 38A = 2090 bu.
Estimate receipt - 1.10 per bu.
price support $2 299.00

- -

Fld. (3) 34 Acres

Seed Beans (Lincoln or Hawkeye)

2 bu/A @ 2.30/bu. $ 156.40 $ 156.40

YIELDS - 24 bu/A x 34/A - 816 bu.
Estimate price - $1.90 at harvest time $1 550.40

Apply ls. and phosphate after plowing before seeding.

- -

1950 PLANS (CONT'D)

Fld. (4) 35 Acres

To Corn
9 lb/A @ 20 cents $ 1.80
Nitrogen 200 lb. NH_4NO_3 7.60

$ 9.40 x 35A - $ 329.00

YIELDS - 55 bu/A x 35A - 1925 bu. @ 1.10 - $ 2 117.50

Fld. (5) 36 Acres

Seed to Oats
Seed 1 1/2 bu/A @ 70 cents $ 1.05
20 lb. Lespedeza No.19604 @ .09 1.80

$ 2.85 x 36A - $ 102.60

YIELDS - 35 bu/A x 36A - 1260 bu. x .55 - $ 693.00
Lesp. Hay 1.5T/A @ $15.00/Ton
54 Ton x $15 - $ 810.00

Total Receipts - $ 1 503.00

CLASS III LAND - RED

Fld. A. 11 Acres (Estimate)

Plant to corn (Do not plow thru the gullies)
9 lb/A @ 20 cents $ 1.80

Top-dress Nitrogen 200 lb. NH_4NO_3
3.80 cwt. 7.60
$ 9.40 x 11A - $ 103.40

YIELDS - 40 bu/A 11A = 440 bu. @ $1.10 - $ 484.00

Fld. B_1 and B_2 - Treat as one field this year. Pull old saplings, etc. and get ready for beans

15 Acres
60 lb/A @ 6 cents/lb. - $3.60/A x 15 - $ 54.00

YIELDS - 20 bu/A 15A = 300 bu A $1.90 - $ 570.00

1950 PLANS (CONT'D)

Fld. C_1 & $_2$ &$_3$ 30.5 Acres

Treat as one field. Ls and phosphate this spring if possible.

Seed to oats	Cost/A	
Oats - 1 1/2 bu/A @ .70	$ 1.05	
Legume mix	7.05	
Alfalfa 6 @ .65 - $3.90		
Red Cl. 4 @ .60 - 2.40		
Tim. 3 @ .25 .75		
Fertilizer 100 lb. 0-20-20 @ $60/T	3.00	
	$ 11.10/A x 30.5A -	$338.55
YIELDS - 35 bu/A x 30.5A = 1,067.5 bu. @ .55		$587.13

Bale <u>all</u> oat straw to use for winter roughage and bedding

- -

BOTTOMLAND (<u>GREEN</u>)

Fld I 14 Acres

Seed to Beans - 2 bu/A $ 4.60 x 14/A - $ 64.40

YIELDS - 24 bu/A x 14A = 336 bu. @ $1.90 - $638.40

(Apply Ls and rock phosphate as needed ahead of seeding)

- -

Fld II 16 Acres

Pull Saplings - prepare field

Plant to corn		
9 lb/Corn @ 20 cents	$ 1.80	
200 lb. NH_4NO_3 (top or side dressing)	7.60	
	$ 9.20 x 16/A	- $147.20
YIELDS - 50 bu/A x 16A - 800 bu. @ $1.10/bu.		- $880.00

- -

1950 LIVESTOCK PROGRAM

Buy 70 head of steers from Aug. 15-30 @ 23 cents lb. weighing 550 lb.

70 head - $126.50/head $ 8,855.00

Turn on pastures, after meadow math., bean fields, cornstalk, etc.

Aug. 15 - Dec. 1 - 105 days - weight about 600 lb. Dec. 1.

Winter Feeding Period

Dec. 1 to April 15 - about 135 days.

Feed so that they gain about 1 lb. per day or so they will weigh approximately 725-750 lb. when they go on pasture.

Winter Ration

16 lb. hay per day - mixed legume -
x70

1120 lb. per day for herd x 135 days = 75.6 tons

x $15.00/ton

Total cost of hay - $ 1,134.00

About $285 of this bill until Dec. 1, - rest 1951 year's cost figures. About 18 tons of the 75.6 tons will be used in 1950.

See Summary Sheet for total expenses for each enterprise. The inventory value carried to 1951 on the steers is based on 625 lb. weights at 23 cents per pound.

1951 CROP PLANS (CONT'D)

BOTTOM

I 14 Acres

Corn

9 lb/A @ 20 cents	$1.80	x	14	$	25.20
YIELD: 55 bu/A x 14 770 bu. @ 95 cents				$	731.50

- -

II 16 Acres

Beans

1.5 bu/A @ 1.90	2.85	x	16	$	45.60
Ryeseed 1.5 bu. @ 1.25	1.87	x	16		30.00
				$	75.60
YIELD: 24 bu/A x 16A - 384 bu. @ 1.90				$	729.60

- -

1 9 5 1

Instead of cutting the hay for hay as estimated - cut

Fld 1 for silage - 8 ton/A 36A = 288 tons
Fld C_1 and $_2$ silage " 20 - 160

448 tons - 392 tons needed

- -

Hay needed - 84 tons

Hay produced - Lespedeza - 51 tons
Baled oat straw will make the rest of the forage needed.

Yields and receipts should vary but little from estimates so no changes are made. I believe this method of harvesting the hay is a great improvement in quality of feed than relying on hay only.

- -

1951 FIELD AND CROPPING PLAN

Fld (1) 36 Acres

Hay

YIELD: 2.2 tons x 36 = 79 tons @ $14.00 $1 106.00

Fld (2) 38 Acres

					Cost/A		
Seed to oats							
2 bu/A @ 70 cents					$ 1.40		
Grass-Legume seed					6.20		
Alfalfa	6	@	.60	3.60			
Red Cl.	4	@	.50	2.00			
Tim.	3	@	.20	.60			
Fertilizer - 100 lb. 0-20-20 @ 3.00					3.00		
					$10.60/A x 38	-	$ 402.80
YIELD: 35 bu/A x 38/A = 1330 bu. @ .55						-	731.50

Fld (3) 34 Acres

Oats

2 bu/A	$ 1.40		
Lespedeza seed 9 cents/lb. - 20 lb.	1.80		
Fertilizer 0-20-20	3.00		
	$ 6.20 x 34A	-	$ 210.80
YIELD: Oats - 35 bu/A x 34A - 1190 bu. @ .55		-	$ 654.50
Lesp. Hay - 1.5T/A x 34 - 51 tons @ $14		-	714.00
			$1 368.50

Fld (4) 35 Acres

Corn

Seed 9 lb/20 cents	$ 1.80		
Fertilizer	7.60		
	$ 9.40/A x 35A	-	$ 329.00
YIELD: 45 bu/A x 35A - 1575 bu. @ .95		-	$1 496.25

1951 CROP PLANS (CONT'D)

Fld (5) 36 Acres

Corn

Seed 9 lb/A @ 20 cents	$ 1.80	
200 lb. NH_4NO_3 3.80 cwt.	7.60	
	$ 9.40/A x 36A =	$ 338.40
YIELD: 55 bu/A 36A 1980 bu. @ .95		$1 881.00

CLASS III (Red) Land

Flds A - 11)
B_1 - 7) 26 Acres
B_2 - 8)

Oats seed 2 bu/A			$ 1.40	
Hay seed			6.20	
Alfalfa	6	.60	3.60	
Red Cl.	4	.50	2.00	
Timothy	3	.20	.60	
Fertilizer			3.00	
Total Cost			$ 10.60 x 26A -	$ 275.60
YIELD: 35 bu/A x 26A = 910 bu. @ .55				$ 500.50

C_1 10 Acres

Corn

1.80/A Seed (9 lb/A @ 20 cents) $ 18.00

YIELD: 55 bu/A x 10 = 550 bu. @ 95 cents $ 522.50

C_2)
C_3) 20 Acres

Hay

YIELD: 2.2 tons per acre x 20 = 44 tons @ $14.00 $ 616.00

1951 LIVESTOCK PLAN

The 70 steers weigh 625 lb. each Jan. 1, and are to weigh 725-750 by April 15. The remaining winter ration and cost is:

57 tons of hay @ $14.00	-	$ 798.00	
Corn and cob meal	-	484.00	
Total Cost			$ 1 282.00

On April 15 they will weigh an estimated 725 lb. each.

PASTURE

From April 15 until July 10 - on pasture alone.

If they gain 10 lb. each in April, 80 lb. in May, 60 lb. in June and 10 lb. to July 10, at that date they will weigh about 875 pounds.

FATTENING PERIOD

Feed the steers on pasture nearest the barn area. If fed from July 10 to Sept. 30 - 82 days, and if they gain 2.5 lb. per day, they should weigh 1,080 lb. by Sept. 30. Estimate they will average 1,050 lb. and sell for 23 cents (purchase price - no margin).

The gross receipts on 73,500 lb. of beef will be - $16 905.00

FEED REQUIRED DURING FATTENING PROGRAM:

Hay	- 7# x 70 x 82 =	20 tons of leg. hay	@ $14.00	-	$ 280.00
Shelled Corn	-15# x 70 x 82 =	1435 bu. corn	@ $ 1.00 bu.	-	1 435.00
Protein Sup	- 1# x 70 x 82 =	2.87 tons	@ $80.00	-	229.60
					$1 944.60

Sept. 1, 1951 - buy 200 head hi good steers weighing 550 lb. @ 20 cents.

Clean up period until December 1, 1951

31 days wintering on:

28# Grass-leg. silage -	86.8 tons @ $6.00		$ 520.80
6# Hay - mixed (& straw) -	18.6 tons @ 12.00		232.50
		Total	$ 753.30
	Total Feed Costs		$3 979.90

CLOSING INVENTORY

Steers weigh 650 lb. @ 20 cents (no margin) x 200 = $ 26 000.00

By letting hogs run with the steers while on feed, some of the waste corn can be salvaged.

Buy 23 hogs weighing 100 lb. for $15/cwt. -	$345.00	cost
By October hogs will weigh 237 lb. each @ 15 cents		
5451 lb.	817.65	

(See Summary Sheet)

1952 FIELD AND CROPPING PLAN

Fld. (1) 36 Acres <u>Corn</u>

Cost $1.75/A x 36 Acres $63.00

Yield 67 bu/A x 36 Acres = 2,412 bushels @ .90 - $2 170.80

Flds. (2) & (3) 72 Acres Hay cut for grass silage
Yield 5 Tons/A - 360 Tons @ $6.00/Ton - $2 160
(1st cutting only for silage)
2nd cutting, 72 acres yielding 3/4 T/A -
54 x 12 648
$2 808

Fld. (4) 35 Acres <u>Oats</u>

2 bu/A @ .60	$1.20 x 35	$42.00
Grass & legume seed	6.20 x 35	217.00
Alfalfa 6 60		
Red Cl. 4 50		
Timothy 3 20		
Fertilizer 100 lb/A		
0-20-20	3.00 x 35	105.00
		$364.00

Yield 35 bu/A 35 Acres - 1,225 bu. @ .50 612.50

Fld. (5) 36 A <u>Corn</u>

Seed $1.75/A 36 Acres $63.00
Yield 67 bu/A 36 Acres - 2,412 bu. @ .90 $2,170.80

Class III (red)
A) 36 Acres - Cut 6 Acres for silage 1st cut 5 T/A
B) - 30 T. Silage @ $6.00 - $180.00
C) Hay - second cut on 6 Acres. Total of 4 Tons
Hay 30 A x 2.2 T/A 66 Tons
70 Tons @ 12.00 - 840.00
$ 1 020.00

C_1 Oats, 10 Acres

Seed	$1.20 x 10 -	$12.00
Legume seed	6.20 x 10 -	62.00
Fertilizer	3.00 x 10	30.00
		$104.00

Yield: 35 bu/A 10 Acres - 350 bu. x .50 - $175.00

C_2 Corn 10 Acres
Seed $1.75 x 10 - $17.50

Yield: 55 bu/A x 10 - 550 bu. @ .90 - $495.00

1952 PLANS (CONT'D)

Bottomland
I 14 Acres Beans

Seed	\$3.65/A	x	14	-	\$51.10
Rye Cover Crop	1.50/A	x	14		21.00
					\$72.10

Yield: 24 bu/A 14 Acres - 336 bu. @ \$1.90 - \$638.40

II Corn 16 Acres

Seed \$1.75/A x 16 \$28.00

Yield: 67 bu/A, 16 Acres - 1,072 bu. @ .90 - \$964.80

1952 LIVESTOCK PLAN

Steers weigh 650 lb. valued at \$26,000 on January 1. Ration for wintering continued from December 31, 1951.

28 lb. grass silage	305.2 Tons	\$6.00 -	\$1 831.20
6 lb. hay	65.4 Tons	12.00 -	784.80
COST			\$2 616.00

Summer Pasture - April 15, Weight 725-750

Gain April 10
May 80
June 60
150 pounds 150
\$875 July 1

Fattening

Feed 30 days on pasture

13 lb. corn and cob meal, 31 days - 200 head - 1,151 bushels

60 days dry lot

Corn 13.5	61 days x 200 head	2,941 bu.
Protein 1	61 days x 200 head	6.1 Tons
Mixed hay 6.75	61 days x 200 head	41.2 Tons

Total Feed and Cost (Winter & Fattening)

Corn	4,092 bu.	@ .90	\$3 683	
Hay	106.6	@ \$12.00	1 279.20	
Grass silage	305.2	@ 6.00	1 831.20	
Protein	6.1	@ 80.00 T.	488.00	
			\$7 281.40	\$7 281.40

Sell steers October 1 weighing 1,050 lb. for 20 cents. 210,000 lb. of beef - 42,000

September 1, purchase 200 more steers (hi-goods)

550 lb. @ 20 - \$22,000

Clean up period until December 1, 1952

31 days wintering

28 lb. grass silage	86.8 T	\$6.00	\$520	
6 lb. Hay & straw	18.6 T	12.00	230	
			\$750	750.00
TOTAL FEED COSTS				\$8 031.40

Closing Inventory, December 31, 1952

Steers 650 lb. @ 20 cents - x 200 -- \$26,000

Hay Enterprise 1952: Hogs running with the steers while fattening is a worth-while project. For simplicity following estimates are made:

Buy 66 hogs weighing 110 lb. each @ 15 cents -- $1 089.00
By Oct. 1 they will weigh 212 lb. each @ 15 cents 2 099.00

See summary sheet for explanation.

SUMMARY OF CROP YIELDS AND EXPENSES

Fields	Yield	January 1950 estimate of receipts	Seed Cost Crops	Seed Cost Legumes	Fertilizer
(1) 36A Corn	2 412 bu.	$2 170.80	$ 63.00		
(5) 36A Corn	2 412 bu.	2 170.80	63.00		
C_2 10 Acres	550 bu.	495.00	17.50		
II 16 Acres	1 072 bu.	964.80	28.00		
	6 446 bu.	$5 801.40			
(4) 35A Oats	1 225	$ 612.00	42.00	$217.00	$105.00
C_1 10A	350	175.00	12.00	62.00	30.00
	1 575	$ 787.00			
I 14A Beans	336	638.40	72.10		
			$297.60	$279.00	
78A Silage	390 Tons	2 340.00			
72A Hay	54 Tons) - $1 488				
36A	70 Tons)				
	124 Tons				
		$11 054.80			

AFG:lap
2-7-51

THE POTENTIALITIES OF REVEGETATING AND UTILIZING AGRONOMIC SPECIES ON STRIP MINED AREAS IN ILLINOIS

•

A PROGRESS REPORT

COVERING THE FIFTH YEAR OF WORK ON A COOPERATIVE INVESTIGATION

CONDUCTED BY

UNIVERSITY OF ILLINOIS, AGRICULTURAL EXPERIMENT STATION

AND

ILLINOIS COAL STRIPPERS ASSOCIATION

NOTE

The agreement covering this investigation provides that:— "No account of a cooperative research project shall be published by the sponsor or by any other agency, except upon approval of the division of the University, or head of the department in which the work is being done."

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FOREWORD

To Members of Illinois Coal Strippers Association

Gentlemen:

On February 1, 1947, Illinois Coal Strippers Association entered into an agreement with the Agricultural Experiment Station, University of Illinois, covering a project of cooperative research into the possibilities of revegetating and utilizing grasses and legumes on strip mined areas for stock range and other purposes.

This project was originally set up on an estimate that it would require five years of research in order to arrive at sound conclusions. It has, however, been extended for three more years and is now entering upon its sixth year. A progress report covering the first year of operation issued on March 19, 1948 dealt principally with the proposed scope and plan of attack on the problem; a survey of spoil bank soils found throughout the state, and preliminary reports on a number of seeding projects. The second report was issued on March 15, 1949; the third report issued on March 6, 1950 and the fourth report, issued on March 1, 1951, presented further information on spoil bank soil materials, and comparisons of such materials with surface soils found on adjoining land; the adaptation of various forage species to spoil bank soils; the results of preliminary studies of comparative gains made by animals pastured on spoil banks with those pastured on undisturbed blue grass and highly improved grass-legume pasture and the utilization of stripped land for pasture.

The report here presented covers the fifth year of operation. It is expected that a consolidated final report, covering the first five years of the program, will be made some time during 1952.

The studies to be made during the next three years will carry on the uncompleted work of the present research program and, in addition, will include several other phases of the strip mining problems dealing with grading, types of overburden, compaction, drainage, organic matter content, pasture carrying capacities, pasture management, weed and brush control, etc., and a report will be issued each year as the program progresses.

A J Christiansen
Secretary

April 1, 1952

Agric.

AGRONOMY PROJECT

NUMBER: 1003 - Fifth Annual Report.

TITLE: Agronomic Land Use Research on the Mined Areas of the Stripped Coal Lands of Illinois.

OBJECT: The objectives of the project are to investigate the potentialities of revegetating and utilizing agronomic species on the strip-mined areas in Illinois.

LEADERS: A. L. Lang, J. A. Jackobs, J. N. Spaeth, and R. R. Snapp.

Advisory Committee: -

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M. B. Russell
F. C. Bauer
J. C. Hackleman
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A. J. Christiansen
Louis S. Weber

Agronomist - Alten F. Grandt.

AGRONOMIC LAND USE RESEARCH ON THE MINED AREAS OF THE STRIPPED COAL LANDS OF ILLINOIS

by Alten F. Grandt[1]

The fifth annual report of progress on Agronomy Project 1003, covering the investigations of the potentialities of revegetating and utilizing agronomic species on strip-mined lands is herewith presented. This is a cooperative research project of the University of Illinois Agricultural Experiment Station and the Illinois Coal Strippers Association.

This project was initiated in 1947. At that time it was estimated that at least 5 years would be necessary to thoroughly explore the subject and to gather facts that would be essential to develop the highest potential uses of the mined lands from an agronomic viewpoint. As the result of past research it has been shown that much of the strip-mined land in Illinois can be and is being reclaimed with agronomic species. More research is necessary to study basic problems that have arisen. The Illinois Coal Strippers Association has expressed the desire to continue the project for at least 3 years longer.

Experimental research is being carried on at 25 different locations in 14 counties. Approximately 50 acres on these locations have been used for experimental plots in this project. Figure 1 shows the general locations where these plots have been established.

SOIL INVESTIGATIONS:

Soil Tests of Strip-Mine Soil Material:

As of December 31, 1951, 1,484 soil samples have been collected from the experimental plot areas and all have been tested by the University of Illinois Soil Testing Laboratory. Table 1 shows the average amounts of plant nutrients found in the soil material. The over-all average of these tests shows the acidity

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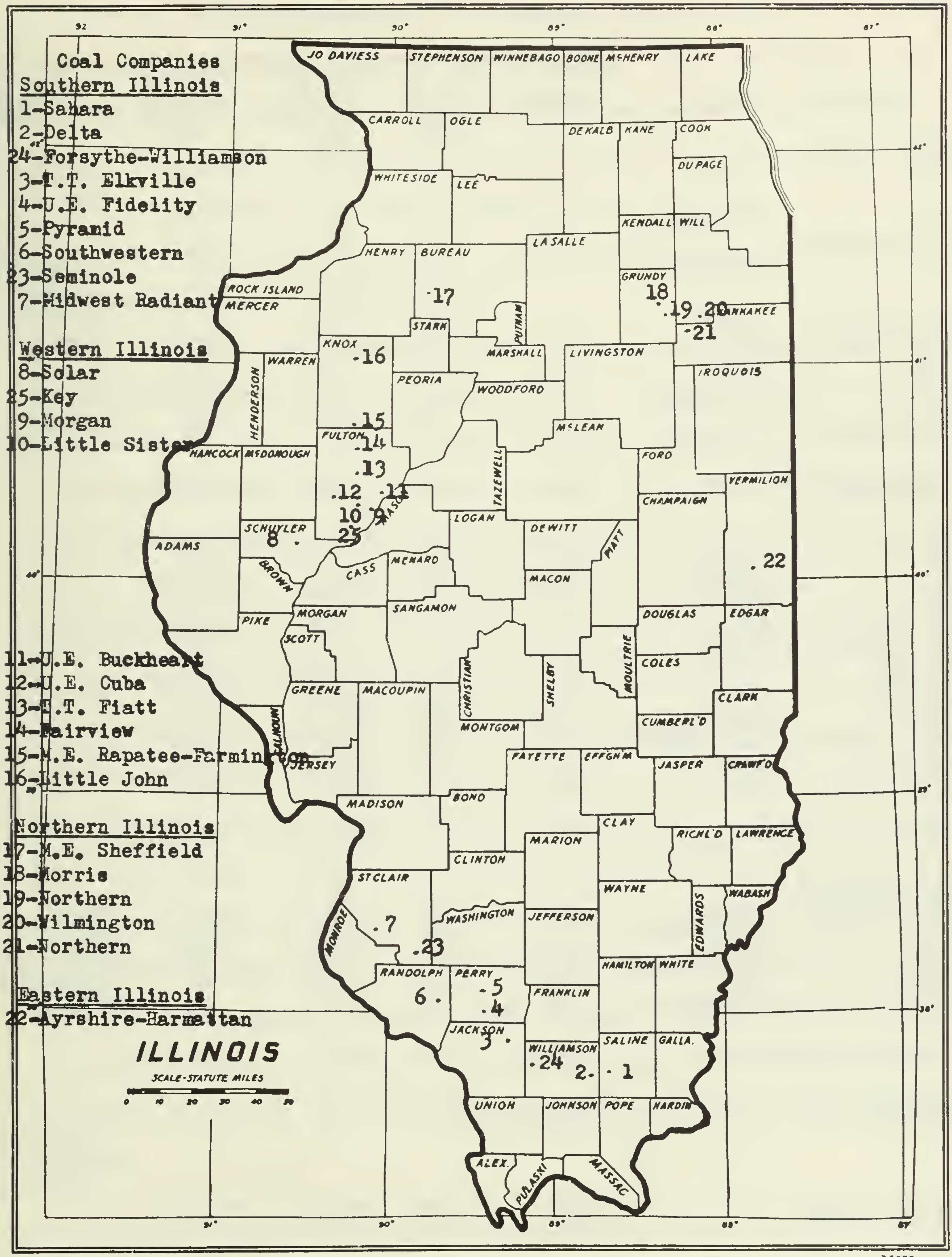
[1] Special Research First Assistant, Soil Fertility, Department of Agronomy, University of Illinois, Agricultural Experiment Station, Urbana.

The author acknowledges with thanks the assistance, advice and encouragement received from L. S. Weber, Land Use Engineer, Illinois Coal Strippers Association, and H. J. Snider, Assistant Professor of Soil Fertility, Illinois Agricultural Experiment Station, in conducting these investigations.



Location of Experimental Plots on Strip-Mined Coal Lands in Illinois
(Fig. 1)

Table 1.--Soil Analysis of Spoil Bank Material

Plot locations	County	Number of samples	Acidity average pH[a]	Phosphorus average lb.[a]	Potassium average lb.[a]	Note
Southern Illinois						
Sahara	Saline	54	4.5	90	169	Shale and S.S. rock
Delta	Williamson	65	6.3	92	134	
Forsythe-Williamson	Williamson	23	6.3	178	169	(Local acid spots
Truax, Elkville	Jackson	55	6.3	117	173	(Frequent acid
U.E. Fidelity	Perry	81	6.6	155	208	(spots
Pyramid	Perry	65	7.3	93	160	
Southwestern	Randolph	34	7.3	82	138	
Seminole	St. Clair	10	7.6	126	168	(Loessal
Midwest Radiant	St. Clair	175	7.1	116	131	(
Subtotal and averages		562	6.6	116.3	156.3	
Western Illinois						
Solar	Schuyler	12	6.8	171	224	
Key	Fulton	16	7.6	107	103	
Morgan	Fulton	10	7.1	178	230	
Little Sister	Fulton	42	7.5	173	190	
U.E. Buckheart	Fulton	48	7.6	112	133	
U.E. Cuba	Fulton	48	7.5	150	160	
T.T. Fiatt	Fulton	114	7.8	146	149	
Fairview	Fulton	54	6.7	144	172	
Midland Electric	Fulton-Knox	155	7.2	156	164	
Little John	Knox	87	6.9	174	192	
M.E. Atkinson	Henry	38	7.3	174	288	
Subtotal and averages		624	7.3	153	173	
Northern Illinois						
M.E. Sheffield	Bureau	89	7.4	152	217	Shaly
Northern Illinois	Grundy-Will	87	6.9	142	192	Shaly
Morris	Grundy	28	3.1	84	144	Highly acid
Wilmington	Will	32	7.6	56	170	(Compact and
Northern Illinois	Kankakee	40	7.6	110	184	(plastic
Subtotal and averages		276	6.9	125	191	
Eastern Illinois						
Harmattan	Vermilion	22	6.7	58	201	(Compact and plastic; reddish material high in sand)
Total and averages		1,484	6.97	132	171	

[a] pH - 7.0 neutral; P - 92 lb./A, high; K - 150-200 lb./A, high.

or pH to be 6.97 or nearly neutral, the available phosphorus content to be 132 pounds per acre and the available potassium content to be 171 pounds per acre. One hundred thirty-seven soil samples were taken and tested during the 1951 season. The averages remained practically the same as reported in 1950.

In addition to the samples taken from the plot areas over 400 field samples have been taken. The results obtained have been nearly identical with the averages obtained from the plot areas.

The soil tests show that a very large percentage of strip-mined lands in Illinois is satisfactory for the production of legumes and grasses. Yet wide variations often occur within relatively small areas. Therefore, it should be reemphasized that when contemplating a use for a particular area of strip-mined land, thorough sampling and testing are very important.

The value of soil tests for phosphorus on strip-mined land has been questioned. The assumption of the criticism is that soil tests are not a true measure of phosphate availability on soils with high pH values. Since, especially in western Illinois, the pH at several locations averages over 7.5, this criticism needs clarification. The soil test for phosphorus on this high pH soil reads very high and indicates adequate phosphorus availability. In fertility studies, legumes have shown no stand or yield response to applications of a complete fertilizer (8-8-8) at the rate of 500 to 750 pounds an acre. Good prolific stands of legumes have been obtained without any added fertilizer. Therefore, it is assumed that the legumes are getting adequate phosphorus from the soil material. On the other hand grasses, while giving excellent response to nitrogen fertilizer, have given very little or no further response when additional phosphate has been applied.

Up to this time major emphasis of soil tests has been placed on soil

reaction or pH and the available phosphorus and potassium content. However, the importance of trace elements in strip-mined soil material has frequently been questioned. For example, boron is one of the trace elements that is occasionally lacking in farm soils. Legumes, especially alfalfa, are particularly sensitive to a deficiency of boron (9). The primary effect of boron fertilizer on legumes is to increase the quality of forage. On soils extremely deficient in available boron, an increase in forage yield is noted. Boron is also quite efficient in increasing the seed set of alfalfa and other legumes.

Eight soil samples taken from graded areas in western Illinois were analyzed for the available boron content by the Soil Testing Laboratory at the University of Illinois. The results obtained are listed in Table 2.

Table 2.--Special Soil Test Report for Available Boron

Company	County	pH	Available phosphorus	Available potassium	Available boron	Boron rating
U.E. Buckheart	Fulton	7.4	176	142	10.0	Very high
		7.2	152	178	6.0	High
T.T. Fiatt	Fulton	7.3	204+	254	7.0	Very high
		7.4	204+	224	10.0	Very high
Fairview	Fulton	7.2	204+	208	10.0	Very high
		7.4	204+	224	4.0+	High
M.E. Rapatee	Knox	7.1	204	243	12.0	Very high
		7.2	204	265	12.0	Very high

Farm land soils are classified as low, medium or high in available boron according to the following scale:

Pounds of Available Boron per Acre	Test Rating
0-1	low
1-2	medium
3-6	high
6 plus	very high

Based on this classification these strip-mined soils are high to very high in available boron. The excellent growth of legumes and the good seed set of alfalfa growing on these soils indicate that the plants are getting adequate boron.

Another angle to the boron problem is that excesses may be toxic. Borax is one of the old time weed killers. Consequently, the question has been raised regarding the quantity of available boron in these strip-mined soils that would be toxic to the grasses and legumes. Toxicity effects have not been noticed to date on forage crops growing on these soils.

Mechanical Analysis of Strip-Mine Soil Material:

The mineral particles of a soil range in size from those easily seen, such as rock, gravel and sand, to those not discernible as colloidal materials. The various size particles impart their properties to a soil material, and according to the proportions present, determine to a great degree the physical nature of the soil. The percentage of the various soil-sized particles present also help determine the textural name of a soil. By means of a mechanical analysis the particles of a soil can be separated into groups such as sand, silt or clay, which are referred to as separates. The sands, if dominant, give properties known as sandy, while if the soil is made up largely of silt and clay, its plasticity and stickiness indicate that it is clayey in nature.

Strip-mine soil material is a heterogeneous mixture of rock, slate, shale, sand and gravel, glacial till and loessal material. The larger the percentage of soil-sized particles (2 mm. or less in diameter) present, the greater are the opportunities for successful reclamation providing the chemical composition is not deleterious. As yet the percentage of fine material, less than 2 mm. in size, in the various strip-mine soils in Illinois has not been determined other than

by observation. This will vary with location and age of the mined land. It has been estimated that from 40 to 95 percent of the material is finer than 2 mm.

While the amount of material finer than 2 mm. is important, the percentage of the various separates such as sand, silt and clay in this fine material is also important. Therefore, to help understand the physical properties of the soil material and to assist in the classification (5) or naming of the strip-mined soil material, the mechanical analysis of this finer material was determined. Thirty-nine samples from eight counties have been analyzed. The hydrometer method was used. The material finer than 2 mm. was separated into the following sizes: sand, from 2 mm. to .05 mm.; silt, from .05 to .002 mm.; clay, finer than .002 mm.

The results are listed in Table 3. Fifteen of the 39 samples fell in the textural group known as silty clay loams. Six of the samples would be classified as silty clays, six as clay loams, five as loams, four as silt loams, two as clays and one as sandy loam.

The Effect of Neutralizing Toxic Acid Shales With Limestone:

In previous reports reference has been made to the soil samples that had a very low pH. This condition has been referred to as toxic acid (5) since the pH has been found to be as low as 2.2 and a pH below 3.8 is considered to be toxic to all plants. The presence and resultant weathering of sulfur in the various shale layers is the cause of the acid condition.

Enough material of two of these sulfurous shales was brought into the greenhouse so that the neutralization of the acidity could be studied. One of the shales was a blue-gray shale from southern Illinois, probably Coppers Creek shale. It is quite high in clay. Over 50 percent of the material finer than 2 mm. is less than .002 mm. in size. Thus the physical condition is sticky and

Table 3.--Mechanical Analysis of Strip-Mine Soil Materials Finer Than 2 mm.

Companies	Counties	Soil separates: Sand .05 mm.	Silt .05-.002 mm.	Clay .002 mm.	Textural name
		pct.	pct.	pct.	
Delta Collieries	Williamson	21.6	48.7	29.7	Clay loam
		15.5	53.3	31.2	Silty clay loam
		15.3	55.1	29.6	Silty clay loam
Truax-Traer Elkville	Jackson	14.4	46.7	38.9	Silty clay loam
		18.0	42.0	40.0	Silty clay
		18.2	49.0	32.9	Silty clay loam
		16.8	50.4	32.8	Silty clay loam
		15.0	51.2	33.8	Silty clay loam
U.E. Fidelity	Perry	31.2	42.9	25.9	Loam
		28.2	42.0	29.8	Clay loam
Pyramid	Perry	16.0	55.0	29.0	Silty clay loam
		14.5	55.2	30.3	Silty clay loam
		16.1	57.2	26.7	Silt loam
B. Somers	Fulton	28.8	50.2	21.0	Silt loam
		20.1	54.1	25.8	Silt loam
		15.8	59.8	24.4	Silt loam
		40.2	39.8	20.0	Loam
U.E. Cuba Mine	Fulton	20.6	40.5	38.9	Silty clay loam
		16.7	42.1	41.2	Silty clay
		10.1	49.0	40.9	Silty clay
		10.4	48.3	41.3	Silty clay
T.T. Fiatt	Fulton	11.4	60.3	28.3	Silty clay loam
		15.8	46.6	37.6	Silty clay loam
M.E. Sheffield	Bureau	17.1	40.2	42.7	Silty clay
		25.3	36.0	38.7	Clay loam
		16.1	44.1	39.8	Silty clay loam
		16.7	39.7	43.6	Clays
		19.5	41.1	39.4	Silty clay loam
		19.6	41.3	39.1	Silty clay loam
Northern Illinois Strike-off plot Area	Grundy	40.9	36.0	23.1	Loams
		40.3	39.6	20.1	Loams
		56.8	24.8	18.4	Sandy loams*
Northern Illinois Pit 12	Kankakee	13.7	32.8	53.5	Clays
		25.1	41.7	33.2	Clay loam
		41.6	28.3	30.1	Clay loam
		12.2	48.8	39.0	Silty clay loams*
Harmattan	Vermilion	39.0	33.8	27.2	Clay loams (reddish)
		40.8	34.0	25.2	Loams (reddish)
		2.7	45.2	52.1	Silty clay (blue-gray)

*From Will county

plastic when wet. After weathering the reaction or pH of this material is about 2.6. There was about 5 percent organic matter in this shale. The other shale was a yellow shale from western Illinois known as the Canton shale. It was found to have about 63 percent of clay finer than .002 mm. in size. After weathering the pH of the material was about 2.3. These toxic acid spots appear as wet looking dark areas that are very compact and hard. According to tests the available phosphorus and potassium content was very high. The organic matter content of the yellow shale was very low with about 1.25 percent recorded.

Known quantities of these shales were placed in pots in the greenhouse and limestone was added at various rates. At first 5 plots in duplicate were treated at the rate of 0, 5, 10, 20 and 40 tons per acre of limestone, respectively. The pots were watered regularly so that neutralization of the acidity could be accomplished. The results are presented in Table 4. On the blue shale, 40 tons of limestone per acre brought the pH up to 7.0. However, on the yellow shale the 40 tons of limestone did not raise the pH up to 7.0 or neutral. Therefore, to 4 pots of the second series more limestone was added. Sixty tons of limestone was required to bring the pH up to and above neutral.

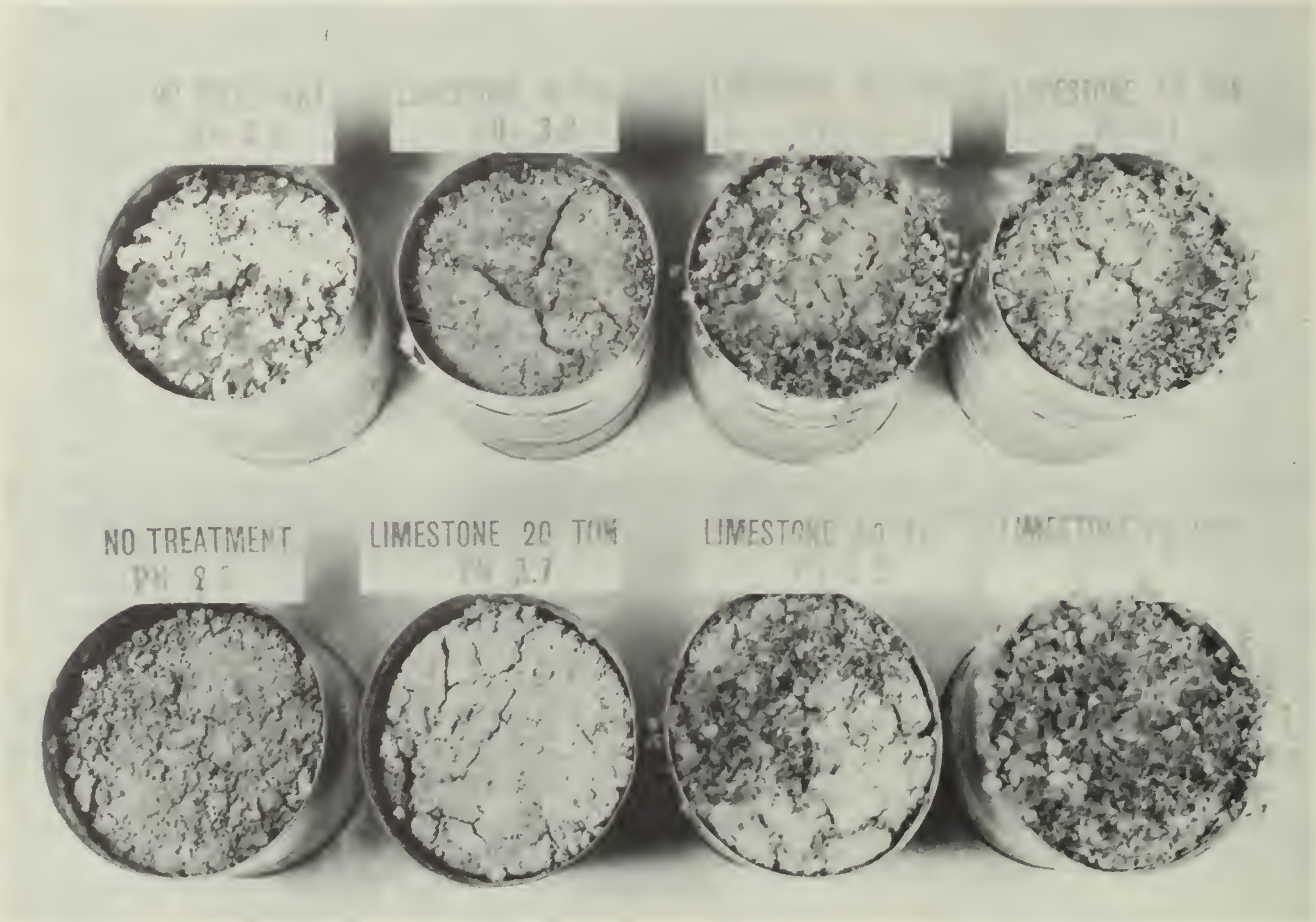
After the shale material had been neutralized, inoculated alfalfa, red clover and birdsfoot trefoil were seeded in the plots. The early legume growth is noted in Table 4. Figure 2 shows the growth of legumes after the limestone treatment.

From this study it appears that toxic acid areas if graded can be neutralized and legumes will grow on such treated areas. However, because of the high clay content and poor physical condition and the extremely large amount of limestone required, reclaiming these toxic acid areas seems impractical. A more logical approach might be to bury any sulfurous materials in the mining operation.

Table 4.—Effect of Liming on Two Highly Acid Shales

Material	Limestone[a] treatment per acre	Soil reaction Before liming	After liming	Legume growth
	tons			
Blue shale Series I	0	2.6	2.8	None
	5	2.6	3.1	None
	10	2.6	3.8	None
	20	2.7	5.7	Fair
	40	2.7	7.0	Good
Blue shale Series II	0	2.7	2.9	None
	5	2.6	3.2	None
	10	2.6	3.7	None
	20	2.55	6.2	Fair
	40	2.6	7.2	Good
Yellow shale Series I	0	2.25	2.4	None
	5	2.25	2.6	None
	10	2.3	3.0	None
	20	2.3	3.7	None
	40	2.3	5.2	Fair
Yellow shale Series II	0	2.3	2.5	Series Relimed
	5	2.3	3.0	
	10	2.3	2.8	
	20	2.25	3.2	
	40	2.3	3.5	
Yellow shale Series II with more Ls. added	0	2.3	2.5	None
	45	3.0	6.3	Good
	50	2.8	6.0	Fair
	60	3.2	7.3	Good
	70	3.5	7.2	Good

[a] Limestone-calcium carbonate chemically pure.



Acid shale study. The effect of adding limestone to (1) blue acid shale (upper) and (2) yellow acid shale (lower) on soil reaction or pH and on the growth of legumes. (Fig. 2)

The Organic Matter Content of Several Strata in the Overburden of Strip-Mine Lands:

In rather limited areas in western Illinois a muck-type soil material has been observed in the upper portion of the overburden. This probably represents an old lake bed. The strata is quite variable in thickness and extremely localized. The material is very dark appearing and high in organic matter.

The organic matter content of this muck material from two locations was determined. In addition a black slatey shale, the blue and yellow acid shales and a random sample of strip-mine soil material was analyzed for organic matter content. The determinations were made by Mr. J. Hemwall of the Soil Physics Laboratory. The percentage of organic matter, the pH and available phosphorus content are presented in Table 5. The organic matter found in these strata may be compared with two farm soils rather common in the western Illinois areas, Muscatine and Clinton silt loams.

Table 5.--Organic Matter Content, Reaction, Available Phosphorus and Potassium of Several Strata in the Material Over the Coal

Strata	Organic matter[a]	pH	Available P_2O_5	Available K_2O
	pct.		lb.	lb.
1. Muck (Knox county)	8.12	6.4	56	40
2. Muck (Fulton county)	7.21	7.0	117	40-
3. Black slatey shale	10.99	6.5	200+	307+
4. Blue shale (acid)	5.09	2.6	200+	300+
5. Yellow shale (acid)	1.23	2.3	200+	300+
6. Random sample of strip-mine soil material in western Illinois	0.50	7.4	204+	192
7. Muscatine silt loam[b]	5.54	6.0	...	...
8. Clinton silt loam[b]	1.85 - 2.45	6.0	...	...

[a] Based on carbon determination.

[b] Unpublished data in files of Soil Survey division.

Physically organic matter is important as it improves the physical conditions and increases the water-holding capacity of soils. Chemically organic matter is a source of plant food materials and biologically it promotes the activity of bacteria and other organisms. In most strip-mine soils the organic matter content is very low. Where present this muck material greatly improves the physical condition of the soil material and where such areas are graded, cultivated crops can be produced soon after grading.

Grading of Strip-Mine Land:

The grading of strip-mine land has greatly increased since 1950. The physical and chemical characteristics of the soil material and the eventual land use are of prime importance when considering grading. In order to determine the effects of grading on soil structure and the resulting growth of forage species, a study on the infiltration rate was conducted. This is the rate at which water passes downward into and through the soil.

Three physical conditions of the mined land were selected, i.e. (1) undisturbed ridges or banks, (2) strike off tops and (3) graded areas (accessible with farm equipment). Each of the three types of physical conditions was analyzed under two phases of vegetation, i.e. (1) well vegetated with legumes and (2) bare of vegetation. These studies were carred out on the two major spoil types, 4-C calcareous silty clays and 4-B calcareous loams and silty shales.

On strike-off tops and on graded areas infiltration rate was determined by means of a 1-foot square sheet iron frame slatted parallel to one edge and supplied with a trough (1). The frame was sunk into the soil with the slot parallel to and at the soil surface. A 1-foot square pan perforated with 100 pinholes was set over the top of the frame, and through this water was poured. As the water dropped onto the soil, part of it was absorbed and the remainder ran off, passed

through the slot and down the trough, and was caught in a cylinder placed in a soil pit alongside the absorption frame. Water was applied at the rate of 5 inches per hour. When the rates of runoff remained the same for two or three consecutive applications, infiltration was considered constant and recorded as such.

For the remainder of the study, that is the ridges, the cylinder method was used (7). Cylinders 8 inches in diameter were forced vertically into the soil material. Calibrated burettes were then placed into position, as shown in Figure 3, filled with water and measurements were started. Readings were taken at 15 minute intervals for 1 hour and at 30-minute intervals for 2 hours. Thereafter, readings were taken hourly for 3 hours, making a 7-hour period during which readings were taken. The infiltration recorded during the sixth and seventh hour was averaged to get the average infiltration rate per hour.

The data obtained are presented in Table 6 and as is indicated by the standard deviations, there was wide variation in the infiltration. This was especially true of the ridges, both bare and vegetated. In general there was not much difference in the infiltration rate on level and strike-off tops, but the ridges had a significantly higher rate of infiltration. Vegetation has increased the infiltration under all three physical conditions. The infiltration rate on the vegetated ridges of the calcareous silty clay, rocky and calcareous loams, loessal, spoil types was very rapid.

Further studies are being made on graded areas, bare and vegetated with the cylinder method to determine the variations in the infiltration rate. This study is incomplete at this time. In one location on a soil material high in blue clay shale, the infiltration of 10 samples averaged about 0.45 inches per hour. The variation in the 10 samples ranged from 0.05 inch per hour to 1.60

Cylinder method of determining the infiltration on the side of bare ridges. (Fig. 3)

Table 6.—Infiltration Rates in Inches per Hour[a] on Four Spoil Types Under Three Different Physical Conditions (level, strike-off and ridges), and Two Types of Cover, Bare and Grass-Legume Vegetation.

Spoil types	Bare			Vegetated		
	Level	Strike-off	Ridges	Level	Strike-off	Ridges
	in.	in.	in.	in.	in.	in.
4-C Calcareous silty clays Fulton county	0.89 ± 0.09	0.75 ± 0.18	9.29* ± 10.10	1.49 ± 0.64	1.83 ± 0.65	13.57 ± 10.33
4-B Calcareous silty shale Fulton and Knox counties	0.70 ± 0.25	0.58 ± 0.38	1.95 ± 0.84	0.91 ± 0.48	1.02 ± 0.48	13.35 ± 5.92
4-C Calcareous silty clay, rocky Perry county	1.39 ± 0.39	1.01 ± 0.43	6.83 ± 5.26	1.43 ± 0.51	1.44 ± 0.22	31.38 ± 24.00
4-B Calcareous loam, loessal St. Clair county	0.42 ± 0.40	1.20 ± 0.36	2.78 ± 3.30	1.71 ± 1.03	1.36 ± 1.01	53.27 ± 19.04
Average	0.85	0.89	5.21	1.39	1.41	27.89

[a] Each figure with its standard deviation is a mean of 10 determinations except * in which 20 determinations were used.

inches per hour. With this great variation noted more recordings are needed to obtain more accurate information as to infiltration or permeability.

Guides have been established to classify the permeability of agricultural soils (8). Seven degrees of permeability will express the most significant variations of the infiltration of most farm soils. The ranges of permeability and some of the soil types that fall into these ranges are:

Description of rate of permeability	Infiltration in inches per hour	Soil Group
Very slow	Less than .05	Cisne - Wynoose silt loam
Slow	0.05 to 0.20	Swygert silt loam
Moderately slow	0.20 to 0.80	Herrick silt loam
Moderate	0.80 to 2.50	Flanagan and Muscatine silt loam
Moderately rapid	2.50 to 5.00	Joy-Port Byron silt loam
Rapid	5.00 to 10.00	O'Neill sandy loam
Very rapid	More than 10.00	Hagener loamy sand

Based on this guide the infiltration rate or permeability of the graded areas, both bare and vegetated, can be classified as moderate. The bare ridges may be classified as rapid and the vegetated ridges as very rapid.

The effects of grading on the reaction or pH of the soil material and on the availability of phosphorus and potassium is presented in Table 7. For the graded area, 238 soil samples from 14 different locations were analyzed while 261 samples from 13 different locations were analyzed for the area not graded. The effect on reaction or pH was variable. In some cases the pH was lowered by grading as found on a calcareous loam (loessal) spoil type on the Midwest Radiant Corporation property. On three locations the pH was raised. The over-all average was a lowering of 0.08 of a unit.

With but one exception the available phosphorus was raised as a result of grading. The average increase was approximately 40 pounds. Five of the areas were raised to 200 pounds plus, so undoubtedly the total was actually raised more

Table 7.--Effect of Grading on Soil Reaction and Availability of Phosphorus and Potassium

Location		Number of samples	pH	P	K	Soil type
Forsythe Williamson	Not graded	11	5.4	157	150	5-C mixed
	Graded (level)	12	7.1	198	184	clays
Truax-Elkville	Not graded	20	6.3	58	155	5-C mixed
	Graded (level)	15	6.0	174	207	clays
Pyramid	Not graded	27	7.4	86	123	4-C calc.
	Graded (S.O.)[a]	22	7.8	78	172	clays
Midwest Radiant	Not graded	13	7.4	116	107	4-B calc.
	Graded (S.O.)	13	6.4	161	125	loams
Little Sister	Not graded	12	7.8	114	145	4-C calc.
	Graded (level)	14	7.2	204	211	silty clay
U.E. Buckheart	Not graded	20	7.7	94	143	4-C calc.
	Graded (level)	12	7.3	148	128	silty clay
U.E. Cuba	Not graded	15	7.6	140	143	4-C calc.
	Graded (level)	16	7.4	204	192	silty clay
Truax-Fiatt	Not graded	28	7.7	144	154	4-C calc.
	Graded (level)	15	7.6	200	191	silty clay
Fairview	Not graded	12	6.3	131	148	4-B calc.
	Graded (1)(S.O.)	12	7.5	141	153	silty shales
	Graded (2)[b](S.O.)	10	7.3	195	196	
M.E. Rapatee (No.5)	Not graded	40	7.7	134	121	4-B calc.
	Graded (level)	40	7.3	200	232	silty shales
(No.6)	Not graded	16	7.4	154	196	4-C calc.
	Graded (level)	12	7.4	188	132	silty clay
Little John	Not graded	16	7.2	167	152	4-C calc.
	Graded (S.O.)	20	7.2	200	164	silty clay
M.E. Sheffield	Not graded	26	7.4	152	285	4-B calc.
	Graded (level)	10	7.3	198	261	silty clay
Northern Illinois	Not graded	5	8.0	151	150	4-B calc.
	Graded (S.O.)	15	7.2	154	179	silty shales
Over-all Average	Not graded	261	7.79	138.3	155.5	
	Graded	238	7.70	177.8	194.8	
	Plus or minus for grading		-0.08	+ 39.5	+39.3	

[a] Strike-off, top of ridge knocked off.

[b] Two different locations graded.

than 40 pounds per acre. The available potassium content was higher after grading than prior to grading in all but three instances. The average increase was approximately 40 pounds per acre.

There may be several explanations for these phenomena: (1) the mechanical breaking of the clay mineral tends to expose the nutrient material and make it more available at least temporarily, (2) wetting and drying of freshly exposed material affects the availability of potassium. Thus over a long period of time the availability of potassium would be expected to increase even though no grading was done (3) sulfur has the tendency to make phosphorus more available. Spreading the sulfur around may tend to accomplish this. The presence of sulfur also has an effect on the soil reaction or pH, causing the soil to be more acid. However, the abundance of calcium and magnesium probably neutralizes the increased acidity.

The growth of forage plants on graded areas is the ultimate means of measuring the effects of grading. If the forage plants will not grow on graded areas, all the other measurements have not measured the controlling or limiting factor. However, from the studies made on forage growth and where the physical and chemical composition of the soil material is favorable, grading has not retarded the growth of forage. Rather grading has several beneficial effects. Less seed is required per acre, thicker stands have been obtained, weeds can be controlled easier, and the excess forage material can be harvested as hay as well as pasturage.

Determination of the Slope of the Ridges of Mined Land:

The stripping shovel deposits the soil material in the overburden in the form of long parallel ridges. These ridges may rise 20 feet or more above the original surface of the ground. The slopes of the ridges are generally

quite steep. Slope measurements made at a number of locations on newly mined ridges ranged between 40 and 65 percent with about a 55 percent slope being typical. Measurements made at one location in 1948 on new ridges averaged 59 percent. Three years later, in 1951, the same ridges averaged about 50 percent. This indicates approximately a 10 percent decrease in the degree of slope as a result of 3 years of weathering and settling of the soil material.

Another report on the settling of the ridges was recorded by Coxton (3). Long wire stakes were placed in the peaks of newly formed ridges. Measurements indicated that the ridges lowered about 2 feet during the first year.

FORAGE CROP SPECIES ADAPTATION STUDIES:

The number of experimental plots that have been established since 1947 is over 2,500. Seventy-two different species and varieties of forage and cultivated crop plants have been used to seed these plots. Fertility studies have been made on many of these areas.

Species Adaptation:

Excellent results have been obtained with adapted species of legumes seeded on newly mined lands. By inoculating the legume seeds prior to seeding, nodules generally are produced on the plant roots, and the legume plant is then capable of fixing nitrogen from the atmosphere and making it available in the soil. This is especially important to the growth of grasses on nitrogen and organic matter deficient strip-mined soils. The only source of nitrogen other than the legumes is that from rainfall and that made available through soil microbiological activity.

Legume species that are well adapted include alfalfa, birdsfoot trefoil, red clover, sweet clover, lespedeza and Kudzu. Birdsfoot trefoil continues to be well adapted to strip-mined lands (see Fig. 4) This species gives best results

An established stand of birdsfoot trefoil on strip-mined land in Fulton county.
(Fig. 4)

when seeded as the only legume along with one or two grasses. In its early stages of growth, it does not compete well with other legumes in a mixture. It is important to inoculate the birdsfoot trefoil with the Lotus strain of inoculant for satisfactory results.

The adaptation of several strains of alfalfa varieties has been studied. The nonwinter hardy and nondisease resistant varieties such as Kansas Common and Oklahoma Common that were seeded in 1948 have not persisted. Only a few plots were seeded in 1948 with the hardy, disease-resistant varieties, Buffalo and Ranger. The stands of these varieties are still good.

Eleven varieties or strains of alfalfa were seeded in 1951 on graded strip-mined lands to observe winter hardiness, longevity and yielding capacity. The following varieties are included: (1) Ranger (2) Buffalo (3) Kansas Common (4) New Mexico Common, Roswell, New Mexico (5) New Mexico Common, Hatch, New Mexico (6) Grimm (7) Cossack (8) Dakota No. 12 (9) Chilean (10) African (11) Indian strains from Advance, Arizona.

Winter survival, forage, and seed yields obtained from seven varieties that had been seeded in 1950 are listed in Table 8. Relatively good winter survival was noted for the New Mexico Common strains. The survival of these two strains was better in southern than in western Illinois. Rather poor winter survival and yields were obtained for the three strains, Chilean, Indian, and African. Figure 5 shows alfalfa variety plots on a graded area.

Alfalfa was again cut for seed production in 1951. Some yields obtained are reported in Table 8. Approximately 60 pounds or 1 bushel per acre was the average yield obtained. This is 4 to 6 times less than in 1950. The 1951 growing season was more rainy and much shattering was noted. It is believed that the wet season was largely responsible for the lower yields.

Table 8.--Winter Survival, Forage and Seed Yields from Seven Alfalfa Varieties Seeded in 1950

Alfalfa variety[a]	Winter survival	Forage yield		Seed yield			
		No. of samples	Yield per acre	No. of samples in ave.	1st and 2nd growth	1st cutting hay 2nd cutting seed	1st and 2nd cutting hay 3rd cutting seed
	pct.		lb.		lb./A.	lb./A.	lb./A.
Kansas Common							
Southern Illinois[b]	70.0	3	4 614	4	73.5	54.0	....
Western Illinois[c]	83.8	2	3 307	8	....	39.0	46.5
Buffalo							
Southern Illinois	76.7	1	7 332	5	61.5	30.0	....
Western Illinois	80.1	6	4 155	8	58.1	43.5	80.25
New Mexico Common (Hatch)							
Southern Illinois	88.9	3	4 746	.	....	....	....
Western Illinois	64.5	6	3 909	4	....	....	57.75
New Mexico Common (Roswell)							
Southern Illinois	85.7	2	5 247	.	....	....	....
Western Illinois	58.0	6	3 651	4	....	....	46.5
Chilean							
Southern Illinois	52.9	2	4 582	.	....	....	....
Western Illinois	36.3	6	2 446	4	....	....	25.5
Indian							
Southern Illinois	41.7	2	4 260	.	....	....	....
Western Illinois	24.0	6	2 333	4	....	....	21.0
African							
Southern Illinois	30.8	3	2 959	.	....	....	....
Western Illinois	14.7	6	....	4	....	....	....

a/Alfalfa varieties were seeded March 1950.

b/Southern Illinois 2 sites United Electric Coal Company's Fidelity Mine in Perry county and Truax-Traer Coal Company, Elkville mine, Jackson county.

c/Western Illinois 2 sites Truax-Traer Coal Company's Fiatt Mine, Fulton county and Midland Electric Coal Corporation, Knox county.

Alfalfa variety plots on a graded area in Fulton county, 1951. Note the ungraded spoil ridges in the background. (Fig. 5)

Photo Courtesy of C. Adams

Lespedeza is one of the legume species that is very well adapted to southern Illinois. Good cover and yields are obtained the first year. On many mined areas in southern Illinois lespedeza has completely covered the ridges as the result of volunteer seed. This species in an annual that matures in the fall of the year. The grazing season for lespedeza is in August and September.

As reported earlier, Kudzu has grown remarkably well on mined lands in southern Illinois. Crowns planted in 1948 have survived the rather severe winter of 1950-51. During both the 1950 and 1951 growing seasons, clusters of large purple flowers were produced. In 1951 seed pods were formed but only a few of the pods contained viable seed. The Kudzu planted on the mined land has produced new rootings from the long runners. This has resulted in a more rapid spreading of the plants. However, it is unlikely that under Illinois conditions it will yield as much pasturage as the better adapted legumes and grasses. When used as a pasture it must not be overgrazed, since overgrazing will kill the plant.

Grasses have become established more slowly on strip-mined soils than legumes. One reason is the lack of nitrogen in the soil material. Of the grasses tall fescue, orchard grass and bromegrass become established most rapidly when seeded. Kentucky bluegrass, timothy, redtop and Reed canary grass become established more slowly. Other grasses that have been established to varying degrees on mined lands include tall oatgrass, western wheat grass, crested wheat grass, Canadian wild rye, switch grass and bluestems. Some of these latter species will probably not be used intensively in Illinois since the more common grasses are more available and often more desirable pasture species.

The establishment of a good grass cover takes at least 2 years and often longer. On many plots that were seeded in the spring of 1948 with a mixture of

grasses and legumes, grasses were dominant in 1951. As the nitrogen content increases with the growing of legumes, the grasses become more prolific and may crowd out some legumes. Birdsfoot trefoil has withstood the competition from the grasses better than the rest of the common legumes seeded.

Establishment of Mixtures:

Better pastures usually result where a mixture of grasses and legumes is seeded than where a single species is seeded. Based on past results the most satisfactory stands have been obtained by seeding both grasses and legumes in the spring of the year on newly-mined ridges. During the first several years, the growth is dominantly legumes with the grasses increasing slowly.

Some yields that have been obtained in 1951 from mixtures seeded at various locations are listed in Table 9. The best yield obtained was from the birdsfoot trefoil-grass mixture seeded in 1948. Mixtures containing alfalfa and clovers generally give higher yields on second and third year seedings than birdsfoot trefoil.

Use of Grain and Seed Crops:

Of the grain crops that have been seeded on mined lands, wheat and rye have generally given good results. The yield of wheat obtained and the fertilizer treatment used on a level area in western Illinois are listed in Table 10. Highest yields, but with the greatest variation, were obtained on the plots where 60 pounds of nitrogen were top-dressed in the spring. Phosphorus and potassium as applied in 60-60-60 treatment did not increase the yield obtained over nitrogen alone. The yields obtained when 20-0-0 or 20-60-60 was applied show that the limiting factor was nitrogen rather than phosphorus and potassium.

Wheat was seeded on a larger scale on the same property. The amount

Table 9.—Yields of Forage Produced on Mined Land Plots, 1951

Forage mixture	No. of samples	Property	County	Type of plots[a]	Yield per acre	
					lb.	tons
Alfalfa-bromegrass	4	Delta	Williamson	A	6 060	3.0
	4	Pyramid	Perry	A	4 336	2.2
	2	Morgan	Fulton	A	4 287	2.1
Alfalfa-orchard grass	4	Delta	Williamson	A	5 612	2.8
	4	Pyramid	Perry	A	4 512	2.3
	2	Morgan	Fulton	A	3 450	1.7
Alfalfa-Alta fescue	4	Delta	Williamson	A	10 282	5.1
	4	Pyramid	Perry	A	4 072	2.0
	2	Morgan	Fulton	A	5 169	2.6
Average					5 309	2.7
Birdsfoot trefoil-bromegrass	4	Delta	Williamson	A	6 594	3.3
	4	Pyramid	Perry	A	6 234	3.1
	2	Morgan	Fulton	A	3 548	1.8
Birdsfoot trefoil-orchard grass	4	Delta	Williamson	A	6 414	3.2
	4	Pyramid	Perry	A	5 388	2.7
	2	Morgan	Fulton	A	6 771	3.4
Birdsfoot-Alta fescue	4	Delta	Williamson	A	7 236	3.6
	4	Pyramid	Perry	A	6 600	3.3
	2	Morgan	Fulton	A	6 939	3.5
Average					6 192	3.1
Ladino and grasses	6	Morgan	Fulton	A	5 611	2.8
Legume and grass mixtures	8	Pyramid	Perry	A	5 288	2.6
	7	Truax (Fiatt)	Fulton (Sheep pasture)	A	5 824	2.9
	7	Truax (Fiatt)	Fulton	A	3 936	2.0
	3	Fairview	Fulton	B	6 285	3.1
Average					5 333	2.5
Lespedeza	2	Sahara	Saline	C	4 416	2.2
	4	Delta	Williamson	A	3 702	1.9
	3	Truax (Elkville)	Jackson	A	4 088	2.0
	3	Truax (Elkville)	Jackson	C	4 320	2.2
	2	U.E. Fidelity	Perry	A	4 176	2.1
	2	U.E. Fidelity	Perry	C	4 980	2.5
	4	Pyramid	Perry	A	4 032	2.0
Average					4 245	2.1

[a] A - Undisturbed spoil ridges, B - Strike-off tops, C - Level or partially level.

Table 10.—Yields of Wheat on Level Area in Western Illinois, 1951
United Electric Coal Company, Buckheart Mine

No. of plots	Treatment[a]	Yield per acre	Standard deviation
		bu.	bu.
3	Check	4.73	± 1.2
4	20-0-0	17.95	± 3.6
4	60-0-0	27.35	± 8.6
4	60-60-60	20.05	± 2.6
4	60-0-60	22.2	± 2.7
4	20-60-60	18.53	± 5.2

[a] The treatments were applied in the spring, 1951. All plots were fertilized with 150 pounds of 3-12-12 in the fall at planting time.

Table 11.—Yields of Soybeans on Land Area in Western Illinois, 1951
Little Sister Coal Corporation, St. David, Illinois

No. of plots	Treatment	Yield per acre	Standard deviation
		bu.	bu.
2	Check	5.5	± 0.3
4	40-0-0	14.7	± 1.5
4	40-40-40	13.8	± 9.7
4	0-40-40	8.0	± 2.8
2	Manure only	5.3	± 0.5
4	Manure plus 40-0-0	12.4	± 3.5
4	Manure plus 40-40-40	13.7	± 6.5
4	Manure plus 0-40-40	12.1	± 6.2

of wheat combined from a 4-acre area was 74 bushels or 18.5 bushels per acre. The yield on a larger area that was seeded very late was much poorer than on the 4-acre area. It was impossible to get accurate data from this area.

Soybeans were seeded at several locations, both on plot size and field scale, in 1951. Yields were taken from the plots by pulling up all plants in a sample area and threshing with a laboratory machine. The yields obtained are listed in Table 11. Most of the plants on these plots were from 8 to 12 inches high. This is typical of what had been obtained in other years. Most of these soybeans could not have been harvested with a combine. Therefore, while it appears that the yields on fully treated plots may approach 15 or more bushels per acre, most of the plants were not tall enough to have been harvested. A larger area seeded by one of the companies was not harvested for this reason.

However, on a muck-type soil material, the growth of soybeans was quite different. It may be recalled that in 1950, 25 bushels per acre of wheat was harvested from a muck-type soil material. In 1951 soybeans seeded on a similar area that had been graded grew very rank. Twenty-three bushels of beans were seeded on about 12 acres and 436.5 bushels of soybeans were harvested. This is an average of 33.8 bushels per acre. The quality of seed was excellent. This muck-type soil material on mined lands is very limited but where it is found, advantage should be taken of its presence. Such areas can be graded and immediately farmed with grain crops such as wheat, soybeans and corn.

DETERMINATION OF FORAGE YIELDS AND QUALITY:

Measurement of Forage Yields:

On seeded areas that have become satisfactorily established, forage yields have been obtained. This was done by cutting either 2- or 4-foot square areas of forage. The forage was dried, weighed and converted to yields expressed

as pounds and tons per acre. Table 12 gives the yields of forage produced on strip-mined lands in 1949, 1950 and 1951.

In 1951 yields of alfalfa-orchard grass, alfalfa-bromegrass and alfalfa-tall fescue were taken at three different locations with several replications at each location. The average yield of alfalfa and the three grasses was 5,425 pounds or 2.7 tons per acre. The grasses are increasing at the expense of the alfalfa which accounts in part for the relatively smaller yields in 1951. The yields of birdsfoot trefoil plus the three grasses were also taken at three locations. The average yield obtained was 6,169 pounds or 3.1 tons per acre. In general, there was less grass with the birdsfoot trefoil than with the alfalfa. Legume-grass mixtures were cut at 4 different locations. The average yield, three cuttings per season, was 4,948 pounds or 2.5 tons per acre. With one exception these yields were obtained from the sides of undisturbed ridges. The rainy season at harvest time was responsible for not harvesting the 1-acre plot in Knox county on graded area. After another season, larger plots on level areas will be harvested and yields obtained.

Lespedeza was again cut in southern Illinois on seven different locations. The average yield obtained was 4,186 pounds or 2.1 tons per acre. A comparison of yields from undisturbed ridges and leveled areas was made. The average yield from the graded area was 4,629 pounds or 2.3 tons compared to 3,999 pounds or 2.0 tons per acre on the undisturbed ridges.

Three-year average yields of forage produced on strip-mined lands in Illinois from 1949-51 is presented in Table 12. Over the 3-year period, alfalfa and birdsfoot trefoil have given the highest yields. These yields, 3.4 tons per acre for alfalfa-grasses and 3.3 tons per acre for birdsfoot trefoil-grasses, compare very favorably with yields obtained on treated farm lands. Burlison (2)

Table 12.--Three Year Average Yield of Forage Produced on Strip-Mined Lands in Illinois, 1949-51

Mixtures	Year	Yield per acre		Average	
		lb.	tons	lb.	tons
Alfalfa and grasses	1949	7 624	3.8		
	1950	7 067	3.5		
	1951	5 425	2.7		
Average				6 705	3.4
Birdsfoot trefoil and grasses	1949	6 912	3.5		
	1950	6 811	3.4		
	1951	6 169	3.1		
Average				6 631	3.3
Legumes and grasses	1949	3 477	1.7		
	1950	4 702	2.4		
	1951	4 948	2.5		
Average				4 376	2.2
Lespedeza and grass	1949	4 086	2.0		
	1950	3 350	1.7		
	1951	4 186	2.1		
Average				3 874	1.9
Ladino and grasses	1950	5 968	3.0		
	1951	5 611	2.8		
Average				5 790	2.9
Red clover and grasses	1949	4 195	2.1		

reports some yields that may be expected from several mixtures on Illinois farm land: (1) fertilized alfalfa-bromegrass, 2.8 tons (2) fertilized timothy-clover, 2.5 tons and (3) fertilized lespedeza grass, 2.3 tons of dry forage per acre.

Forage yield data is helpful in determining the carrying capacity of strip-mine pastures. The following guides can be used to calculate the amount of pasture that will be needed if the number of livestock to be pastured is known (2). A 2-year old steer eats about 125-150 pounds of green forage a day (equivalent to about 25-30 pounds of dry forage). A year old steer eats about 80-100 pounds of green forage (16 to 20 pounds of dry forage). A mature ewe sheep eats about 25 to 30 pounds of green forage a day (5 to 6 pounds of dry forage).

Using this guide, an acre of alfalfa-grass mixture that would produce 6,700 pounds of dry forage would provide about 223 days of grazing for a 2-year old steer. The grazing season in Illinois is seldom over 200 days. Also livestock does not utilize all the forage produced since some is lost through trampling and other causes. Therefore, on strip-mined lands where good stands of forages have been obtained, 2 acres per animal unit over a long pasture season should provide adequate grazing if properly managed.

Chemical Composition of Forage Species:

The chemical composition of forage growing on strip-mined land in 1950 is presented in Table 13. Samples of the various forages were collected from the several spoil types at different locations and at various times of the year. Most species were sampled at the bloom stage of growth.

This study of chemically analyzing forages growing on strip-mined lands has been continuous since 1948. Table 14 lists the average composition of the forage species during a 3-year period, 1948-51. A rather large amount of samples of the common species has been analyzed. Four hundred twenty-five legume and 216

Table 13.—Chemical Composition of Forage Crops Grown on Strip-Mined Land in 1950

Crop	No. of samples	N[a]	Protein	P[a]	K[a]	Ca[a]	Mg[a]	Mn[a]	Si[a]
		pct.	pct.	pct.	pct.	pct.	pct.	pct.	pct.
Legumes:									
Alfalfa	13	2.98	18.6	.20	1.81	1.82	.39	....	....
Sweet clover									
1st year	1	3.32	20.8	.24	1.52	1.86	.69	....	....
2nd year	5	3.08	19.2	.24	1.99	1.57	.34	....	....
Red clover	4	2.71	16.9	.20	1.83	1.68	.34	....	....
Mammoth red clover	1	2.80	17.5	.25	2.25	1.74	.52	....	....
Alsike	1	3.44	21.5	.32	2.08	1.82	.37	....	....
Ladino	6	4.02	25.1	.33	2.31	1.58	.28	....	....
Birdsfoot trefoil									
Italy variety	16	2.89	18.1	.19	2.05	1.29	.32	....	....
New York variety	4	2.57	16.1	.21	1.86	1.21	.34	....	....
Korean lespedeza	11	2.37	14.8	.26	.94	1.33	.18	....	....
Kobe lespedeza	2	2.47	15.4	.29	.78	1.21	.23	....	....
Sericea lespedeza	4	1.92	10.7	.18	.84	1.04	.17	....	....
Kudzu leaves	6	3.16	19.8	.24	1.45	2.37	.34	....	....
Sanfoin	2	2.24	14.1	.23	.88	1.11	.30	....	....
Winter vetch	1	4.20	26.2	.31	2.45	1.13	.29	....	....
Grasses - hay stage:									
Orchard grass	23	1.55	9.7	.25	2.45	.34	.18	.0132	1.80
Tall fescue	17	1.57	9.8	.27	2.26	.33	.18	.0099	2.93
Bromegrass	16	1.73	10.8	.23	2.23	.33	.11	.0076	1.49
Kentucky bluegrass	9	1.78	11.1	.23	1.62	.39	.12	.0071	2.28
Redtop	8	1.16	7.3	.23	1.63	.39	.13	.0244	2.98
Timothy	7	1.38	8.6	.22	1.50	.30	.10	.0075	1.38
Reed canary grass	8	2.09	13.1	.27	2.72	.34	.13	....	....
Tall oatgrass	4	1.45	9.1	.26	2.48	.29	.09	....	1.08
Canadian wild rye	1	1.80	11.2	.16	1.42	.52	...	....	....
Rhodes grass	1	1.20	7.5	.13	1.05	.30	.05	....	4.85
Side-oat grama	2	1.12	7.0	.07	.90	.39	.11	....	3.55
Western wheat grass	2	1.19	7.4	.19	1.37	.30	.10	....	....
Big bluestem	4	.78	4.9	.17	.91	.30	.10	....	....
Little bluestem	4	.81	5.1	.20	.67	.35	.13	....	....
Indian grass	4	.62	3.9	.14	.76	.39	.13	....	....
Switch grass	6	.94	5.9	.22	.61	.39	.23	....	....

[a] N - nitrogen; P - phosphorus; K - potassium; Ca - calcium; Mg - magnesium; Mn - manganese; Si - silica.

Table 14.--Average Chemical Composition of Forage Crops Grown On Strip-Mined Land Over a Period of Years, 1948-51

Species	No. of samples	N	Protein	P	K	Ca	Mg	Mn	Si
		pct.	pct.	pct.	pct.	pct.	pct.	pct.	pct.
Legumes:									
Alfalfa	61	2.92	18.3	.21	1.69	1.68	.42	.0044	.057
Red clover	45	2.65	16.6	.19	1.75	1.55	.42	.0087	....
Ladino	38	3.38	21.1	.27	1.98	1.48	.45	.0016	....
Alsike	39	2.91	18.2	.24	2.10	1.30	.54	.0144	....
Birdsfoot trefoil	55	2.70	16.9	.21	1.84	1.41	.52	.0076	....
Lespedeza	40	2.17	13.6	.23	1.00	1.09	.26	.0085	....
Sweet clover, 1st year	33	3.24	20.3	.23	1.43	1.53	.59	.0066	....
Sweet clover, bloom 2nd year	31	2.99	18.7	.23	1.77	1.44	.44	.0075	....
Mammoth red clover	11	2.80	17.5	.20	1.87	1.51	.53	....	....
Crimson clover	2	2.73	17.1	.16	1.52	2.14	.36	....	....
White clover	8	3.10	19.2	.24	.97	1.75	.55	....	....
Hubam	13	2.98	18.6	.28	1.26	1.38	.56	....	....
Yellow trefoil	15	2.98	18.6	.23	1.96	1.66	.54	....	....
Kobe lespedeza	10	2.05	12.8	.21	.90	1.03	.26	....	....
Sericea lespedeza	10	1.85	11.6	.17	.82	.93	.24	....	....
Kudzu leaves	7	2.70	16.9	.33	2.03	1.49	.39	....	....
Austrian winter pea	1	3.88	24.3	.25	2.12	1.30	.30	.0010	....
Button clover	1	2.16	13.5	.22	1.05	1.24	.56	.0175	....
Lappacea	1	1.42	8.9	.18	.85	1.82	.60	.0360	....
Winter vetch	1	4.20	26.2	.31	2.45	1.13	.29	....	....
Sanfoin	2	2.42	14.1	.23	1.88	1.11	.30	....	....
Crown vetch	1	....	....	.15	1.63	1.25	.47	....	....
Grasses:									
Kentucky bluegrass	18	1.68	10.5	.23	1.41	.34	.20	.0093	1.19
Orchard grass	34	1.67	10.4	.26	2.60	.42	.28	.0244	2.15
Alta fescue	26	1.59	9.9	.26	2.10	.41	.27	.0200	2.32
Bromegrass	24	1.71	10.7	.22	2.28	.44	.30	.0154	1.89
Timothy	17	1.60	10.0	.23	1.95	.35	.18	.0092	1.00
Redtop	21	1.26	7.9	.19	1.55	.42	.22	.0160	2.08
Tall oatgrass	7	1.29	8.1	.17	2.30	.27	.17	.0103	2.93
Reed canary grass	10	2.14	13.4	.19	2.37	.50	.26	....	....
Chewings fescue	2	2.06	6.6	.11	1.48	.36	.11	....	....
Meadow foxtail	1	1.66	10.4	.18	2.40	.38	.18	....	....
Switch grass	7	.88	5.5	.17	.58	.55	.29	....	....
Indian grass	5	.66	4.1	.10	.76	.38	.18	....	....
Little bluestem	4	.71	4.4	.17	.74	.33	.13	....	....
Big bluestem	5	.69	4.3	.16	.77	.30	.12	....	....
Canada wild rye	7	1.57	9.8	.19	1.21	.58	.18	....	....
Michels grass	1	1.84	11.5	.24	....	.36	.15	.0065	1.19
Side-oat grama	4	1.01	6.3	.07	.85	.41	.15	....	....
Rhodes grass	4	1.36	8.5	.18	1.05	.41	.13	....	....
Ryegrass	9	1.69	10.6	.20	1.88	.53	.24	....	....
Western wheat grass	6	1.34	8.4	.19	1.31	.40	.20	....	....
Love grass	4	1.22	7.6	.12	.83	.24	.11	....	....

grass samples have been analyzed during the 3 year period. Because of the large number of samples and the spread over 3 years of the sampling date, the values are considered to be reliable.

However, in studying the chemical composition of plants, it is well to keep in mind the influencing factors that may cause variations. Composition may vary with species, stage of growth, climatic conditions, productivity and mineral content of the soil. Internal or external injuries by insects, diseases, rodents, animals or weather may also affect the composition of vegetation.

In discussing the comparisons of the chemical composition of pasture plants, Fuelleman (4) states that chemical analyses of forages are valuable as they are an aid in the interpretation of pasture experimental results as well as an indication of apparent palatability. They serve as a basis for comparison of the nutritive value of forages. The quantity of protein does not necessarily indicate its quality or digestibility; however, it is true that most high protein forages are apparently more palatable and nutritious than those containing less protein. Similarly, the percentage of phosphorus and calcium are indicators of nutritive value, but it does not mean that they are entirely available to the animal.

Fuelleman (4) further states that the percentages of nutrients in a sample of forage cut on any given date may vary considerably in comparable samples of the same species. This does not imply errors in analysis, in sampling or differences due to soil heterogenity. It is reasonable to assume that the forage itself may be undergoing changes brought about by the synthesis or desynthesis of material.

The nitrogen and protein content of the forage as shown in Table 14 is high. This is especially true of the grasses that must depend mainly on the legumes for their nitrogen. The grasses were sampled at the prebloom to early

bloom stage of growth.

The phosphorus content of strip-mine forage when compared with the phosphorus content of that found under Illinois farm conditions as reported in Illinois Agricultural Experiment Station Bulletin 518 is very high. As discussed earlier some have theorized that the phosphorus in the soil is not readily available at the high pH levels as shown by the soil tests. If this were true, poor plant growth and probably lower phosphorus content of the forages grown on mined lands would result. The reverse is true. There seems to be a good correlation between the very high available phosphorus content as shown by the soil tests and the high phosphorus content of the forages.

The calcium, potassium and magnesium content of the strip-mine forages compare very favorably with that grown on Illinois farms. Based on the chemical composition as shown, the quality of the forage species growing of strip-mined lands is excellent.

Botanical Composition:

A survey of the botanical composition of an established pasture on mined lands was made for a 3-year period. This area was first seeded in 1938 with sweet clover. Grasses and other legumes were seeded later. An excellent stand of forage has been secured. The measurements were made by using a point quadrate. Table 15 shows the frequency that several species contributed to the pasture sward and the percent of bare area.

During the 3 years grasses made up from 65 to 75 percent, the legumes from 20 to 25 percent and weeds from 5 to 10 percent of the species represented. From 6 to 12 percent of the area was bare. Kentucky bluegrass was the dominant specie. Bromegrass, sweet clover and alsike clover were the next most abundant species.

Table 15.--Frequency That Several Species Were Represented in the Sward and the Bare Area in the Lot 1 Pasture in 1948-49-51

Species	1948 April 29	1948 Oct. 7	1949 April 20	1949 Nov. 11	1951 May 4	1951 Oct. 31
	pct.	pct.	pct.	pct.	pct.	pct.
Grasses:	61.0	66.0	68.8	97.8	71.8	77.0
Kentucky bluegrass	36.0	41.0	50.7	65.2	46.7	43.6
Redtop	7.0	7.0	1.6	4.1	1.5	2.8
Timothy	7.0	3.0	3.3	0.8	3.0	0.5
Bromegrass	9.0	10.0	6.3	15.9	14.1	22.1
Wild grasses	2.0	5.0	6.9	11.8	6.5	5.8
Orchard grass	....	....	....	....	....	2.2
Legumes:	23.0	28.0	24.4	1.1	21.6	15.3
Alfalfa	1.0	0.5	0	0	2.5	1.8
Sweet clover	11.0	18.0	12.1	1.1	14.1	4.0
Red clover	6.0	2.0	2.2	0	1.1	1.6
Alsike	4.0	7.0	9.5	trace	3.9	4.6
White clover or Ladino	1.0	0.5	0.6	trace	trace	3.3
Weeds:	8.0	6.0	6.8	1.1	6.6	7.7
Bare:	8.0	6.0	8.3	12.6	5.9	9.0

The use of legumes together with the grasses in strip-mined pasture reclamation is very important. Legumes in general are known to have a high content of protein and minerals and, therefore, are valuable as a livestock feed. The legumes are also capable of fixing nitrogen from the air and making it available in the soil. This is especially important on nitrogen and organic matter deficient strip-mined soils. That the grasses can and do utilize the nitrogen is evident by the growth of grasses obtained and the relatively high protein content of the grasses as shown in Table 14.

As the legumes decrease from the pasture sward due to grazing of livestock and other causes, it is possible to reseed them without extra soil preparation. Livestock hoof tracks provide enough exposed soil material on the ridges that the

legume seeds have a chance to grow. Success has been obtained by seeding alfalfa, sweet clover, Ladino and alsike under such conditions.

Animal Gains as a Method of Measuring Yield and Quality:

During the preceding 3 years, 1948-1950, steers were the livestock used to study the value of forage produced on mined lands. Sheep can and are being used to graze the mined lands at several locations, (see Figure 6). Therefore, it was thought desirable to get some information regarding the possible gains and the effect on the vegetation by grazing with sheep. In 1951 a flock of ewes and lambs was used to study the value of forage produced on mined lands.

The strip-mine pasture that was used for this grazing experiment is located in Fulton county near Fiatt, Illinois, and is part of the Deep Valley Farm's land. An area of approximately 12 acres was selected and divided into 2 nearly equal-sized fields so that rotational grazing could be practiced. The area had been seeded in 1948 and 1949 with a mixture of sweet clover, alfalfa, alsike, Ladino clover, bromegrass, Kentucky bluegrass, tall fescue and timothy. A good cover of grasses and legumes had been obtained. Sheep, cattle, and hogs had grazed the area prior to the 1951 grazing season.

Twenty-six ewes and 29 lambs were processed, weighed and marked and put on one of the pastures on May 18, 1951. The flock was weighed individually on June 20, July 26 and September 10, 1951. The results obtained during the 116-day grazing period and the weights on the several dates are presented in Tables 16 and 17. The data show that the lambs made an average daily gain of 0.29 pounds and the ewes an average daily gain of 0.07 pounds. The gains made by the lambs varied from a low of 0.16 pounds per day to a high of 0.37 pounds per day. One lamb was sick at the last weighing and was not included in this average.

Sheep grazing strip-mine pasture lands in Fulton county, 1951. (Fig. 6)

Table 16.—Data Giving Individual Weights of Lambs During the Grazing Season, 1951

Number	May 18	June 20	Gain or loss 33 days	July 26	Gain or loss 36 days	Sept. 10	Gain or loss 46 days	Total gain or loss
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1	42	59	17	74	15	84	10	42
2	42	62	20	75	13	85	10	43
3	30	48	18	61	13	70	9	40
4	35	49	14	63	14	65	2	30
5	33	48	15	60	12	73	13	40
6	65	87	22	101	14	104	3	39
7	50	59	9	74	15	80	6	30
8	40	54	14	66	12	77	11	37
9	25	40	15	51	11	56	5	31
10	35	46	11	59	13	65	6	30
11	32	47	15	59	12	62	3	30
12	35	52	17	64	12	69	5	34
13	40	48	8	61	13	67	6	27
14	52	64	12	76	12	88	12	36
15	45	54	9	67	13	70	3	25
16	36	52	16	65	13	67	2	31
17	37	54	17	70	16	79	9	42
18	40	56	16	66	10	71	5	31
19	34	49	15	62	13	69	7	35
20	39	55	16	71	16	71	0	32
21[a]	53	67	14	76	9	57	-19	4
22	30	38	8	47	9	49	2	19
23	30	45	15	58	13	68	11	39
24	32	45	13	56	11	69	12	36
25	74	95	19	108	13	110	2	36
26	48	65	17	79	14	89	10	41
27	33	45	12	56	11	66	10	33
28	34	47	13	59	12	59	0	25
29	57	71	14	83	12	86	3	29
Ave. 28	40.18	54.79	14.54	67.54	12.62	73.86	6.32	33.68
Ave. daily gain			0.44		0.35		0.14	0.29

[a] Sick at last weighing, not included in average.

Table 17.--Data Giving Individual Weights of Ewes During the Grazing Season, 1951

Number	May 18	June 20	Gain or loss 33 days	July 26	Gain or loss 36 days	Sept. 10	Gain or loss 46 days	Total gain or loss
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
2	121	134	13	134	0	142	8	21
3	97	107	10	105	- 2	102	- 3	5
25	147	148	1	156	8	155	- 1	8
37	123	125	2	127	2	138	11	15
96	106	107	1	111	4	113	2	7
17	136	141	5	151	10	152	1	16
118	110	115	5	108	- 7	111	3	1
10	88	90	2	89	- 1	91	2	3
4	85	78	- 7	77	- 1	82	5	- 3
11	70	66	- 4	78	18	72	- 6	2
12	103	108	5	115	7	128	13	25
13	99	100	1	102	2	101	- 1	2
14	77	80	3	87	7	97	10	20
22	140	149	9	156	7	125	-31[a]	-15
23	92	95	3	93	- 2	99	6	7
21	75	77	2	81	4	87	6	12
18	125	131	6	129	- 2	130	1	5
26	118	114	- 4	129	15	128	- 1	10
27	103	115	12	110	- 5	110	0	7
28	118	126	8	110	-16	121	11	3
19	124	130	6	130	0	133	3	9
35	119	125	6	119	- 6	134	15	15
13-0	108	119	11	118	- 1	121	3	13
33	92	96	4	99	3	104	5	12
34	127	126	- 1	134	7	132	- 2	5
30	98	102	4	112	10	118	6	20
Ave. 26	107.73	111.69	3.96	113.85	2.16	116.38	2.53	8.27
Ave. daily gain			0.12		.07		.06	.07

[a] Hurt

The flock remained on the first pasture from May 18 to June 20, a total of 33 days. During that period the 29 lambs gained a total of 421 pounds or an average daily gain of 0.44 pounds. The 26 ewes made a net gain of 103 pounds for an average daily gain of 0.12 pounds. A total of 524 pounds was produced from about 6 acres.

The second pasture was grazed from June 20 to July 26, a total of 36 days. The forage was quite mature but abundant. The lambs gained a total of 366 pounds and the ewes a net of 61 pounds. A total of 427 pounds was produced from the second 6-acre pasture.

Because of the need for these two pasture areas by the owner, the sheep were moved from July 26 to September 10 to another pasture area consisting of second-year sweet clover, bromegrass and bluegrass. It was, therefore, impossible to rotate the grazing area as planned. Because of these and other uncontrollable circumstances, it was thought desirable to end the experiment on September 10.

Information on the gains made by the livestock is valuable in determining the value of strip-mined pasture lands. The first year's experiment with sheep revealed many problems, which can be guarded against in future studies. It is hoped that the sheep grazing experiment can be repeated and expanded in 1952.

In 1951 it was again possible to obtain information as to the gains made by several lots of cattle grazing on strip-mined lands. One of these was a herd of cattle owned by Mr. Byron Somers of Fulton county. During the 1951 grazing season, 271 head of steers grazed the 500-acre strip-mined pasture range. One hundred twelve head were rotated on about 180 acres, which were divided into two pastures. The rest of the herd had continued access to the remaining pasture acreage. Two animals from this herd died of bloat and two were killed by lightning.

There were three different groups of steers in this herd. One hundred

twelve head were 2 year olds. These steers grazed the 180 acres of rotated pasture. They weighed an average of 858 pounds per head when turned on pasture on April 26. On September 20 they weighed 1021 pounds, gaining an average of 163 pounds during the 147 days for an average daily gain of 1.12 pounds. These 112 head produced 18,256 pounds of beef in the 147-day grazing period. They were then fed ground corn and protein supplement while grazing the strip-mined pastures until about December 1, 1951.

Another lot of 95 yearling steers weighed 524 pounds per head when turned on pasture on April 26. They weighed an average of 794 pounds per head when taken off the pasture on November 17 after a 204-day grazing season. They had gained 270 pounds each for an average daily gain of 1.32 pounds per head. These 95 head had produced 25,650 pounds of beef in 204 days.

The third lot consisted of 64 head of short yearlings purchased in August. They weighed 513 pounds per head and were in good flesh. On November 17 after a 103-day grazing period, they weighed 573 pounds. They had gained 60 pounds each for an average daily gain of .58 pounds per head. These 64 head produced 3,840 pounds of beef in 103 days.

This herd of 271 head produced a total of 47,746 pounds of beef. This production came from about 500 acres or about 96 pounds of beef per acre. In addition some credit must be given to the pasture during the time the 112 steers were on feed and still grazed the pasture. The pastures could have been stocked heavier as there was a goodly amount of forage that was not utilized. Therefore, at least 100 pounds of beef were produced per acre from the 500-acre pasture range.

During the 1951 grazing season, the Meadowlark Farms, Inc., pastured a total of 219 head of yearling steers and heifers on strip-mine pastures in

Fulton county. The forage was sweet clover, alfalfa, birdsfoot trefoil, bromegrass and bluegrass. These cattle made an average daily gain of 1.6 pounds during a 128-day grazing period. Fifteen of the top animals selected from this herd placed fourth in the Short Feed Special Carlot Class at the 1951 International Livestock show in Chicago.

The Midwest Radiant Corporation property in St. Clair county is starting a livestock program. In 1951 a herd of 22 head of white-faced steers grazed a rather new pasture for 157 days. They gained an average of 201 pounds per head for an average daily gain of 1.28 pounds.

A farmer, Mr. W. Shafer of Maquon, Illinois, pastured 10 head of steers on strip-mine pastures in 1951. These steers were purchased in the fall of 1950 weighing 516 pounds. They were wintered on clover hay and a small amount of oats. They were turned on the pasture on May 3, 1951 weighing an average of 682 pounds per head. On October 18, 1951, after a 168-day grazing period, the steers weighed an average of 904 pounds per head making an average daily gain of 1.32 pounds per head.

ECONOMIC INTERPRETATIONS:

Methods, Costs and Feasibility of Forage Species Establishment:

The methods of seeding the mined areas in the past have been hand seeding, tractor mounted power seeder and air seeding by airplane and helicopter. The length of time required to seed the areas by any method depends to a great extent upon the species seeded. The seed of some of the grass species is very light in weight and bulky and requires more time to seed.

Under good conditions the time required to seed an acre by hand has been from 1 to 1½ hours. Including all labor and supervisory time, it required about 25 minutes per acre to seed a prepared area by tractor seeder. In contrast, from

75 to 125 acres per hour can be seeded by the air method. Whatever method is used, complete and thorough application of a good mixture of seed on the whole area is of prime importance.

The total cost per acre varies greatly depending on the kind of seed or mixture used, the seeding rate per acre as well as the labor and type of equipment used. During the 1951 season, the total costs ranged between $10 and $15 per acre.

Accessibility and Management After Establishment:

There are several degrees to which a mined area may be prepared in developing it for agricultural use. If the area is to be developed for pasture, accessibility throughout is of prime importance. Some have found it expedient to provide access roadways only. The making of roadways has varied to a great degree. Usually too few roadways are constructed rather than too many.

Still others have prepared the area by knocking off the tops of all ridges to a width of from 12 to 16 feet with a bulldozer. The advantages of this method of preparation are that the area is readily accessible to seed either by hand or with tractor mounted seeders, roadways are already made, the management and control of livestock are made easier, and the scenery or sky line is improved.

The highest degree of preparation is to grade the complete area so that farm equipment can be driven over the whole area. The physical texture of the soil material, the soil reaction and nutrient content, and the eventual land use are of prime importance when considering grading. In several areas of Illinois, the high percentage of loess and till material, the low percentage of rock, the chemical composition of the soil material and the methods of mining appear to make grading feasible.

There are several small areas in the mined lands in Fulton and Knox

counties that have a strata of muck-type material of considerable thickness in the overburden. This material is very high in organic matter content averaging between 7 and 8 percent. Where this material is present and the area is graded, a very loose friable soil condition exists. Such graded areas can immediately be used to produce tillable crops. Soybeans and wheat seeded on such areas have yielded 33 and 25 bushels per acre, respectively.

It is important in the maintenance of a good pasture area to be able to control volunteer trees, shrubs and other forms of undesirable growth. On common pasture lands, clipping with a mower is the means of controlling this undesirable vegetation. On strip-mined lands left in ridges, the use of the mower is impossible.

The degree to which volunteer trees, shrubs, etc., are a problem on these lands is often due to early management of the area. If the area is not developed and utilized before volunteer and undesirable growth becomes established, the productive capacity of the pasture is reduced. To restore the productive capacity this growth must be removed. The slow expensive method of hand cutting the undesirable species in many cases does not destroy them permanently since many broadleaved species will sprout vigorously and persistently. However, during the past several years chemicals have been used to control woody growth.

Many of the older strip-mined areas in Illinois are dotted with relatively large volunteer trees which are detrimental to the development and production of good pastures (see Figure 7). The study of methods of killing this growth by the use of chemicals that are nonpoisonous to livestock was started on an experimental basis on strip-mine pastures in the late summer, 1951. The study plots are located in Fulton county on the Byron Somers strip-mine pasture area. Seven and one-half acres of the oldest and most heavily wooded pasture area were treated.

Volunteer tree and other undesirable species such as is shown are detrimental to the development and production of good pastures. (Fig. 7)

Photo Courtesy of C. Adams

EXPERIMENT A:

This experiment was designed to study eight different methods of killing trees. Eight one-half acre plots were established. The several herbicides used were (1) Ammate (ammonium sulfate), (2) Esteron 2,4,5-T (2,4,5 trichlorophenoxyacetic acid, propylene glycol butyl ether ester, 66 percent or 4 pounds per gallon), (3) 2,4-D (isopropyl ester of 2,4 dichlorophenoxyacetic acid, 44 percent or 3.3 pounds per gallon) and (4) brushkiller (2,4 dichlorophenoxyacetic acid, 2 pounds acid per gallon and 2,4,5 trichlorophenoxyacetic acid propylene glycol butyl ether ester, 2 pounds acid per gallon). The treatments are as follows: Plot 1 - check plot - girdling as a means of killing the trees; plot 2 - frill and apply Ammate spray (1 pound Ammate per 1 gallon water); plot 3 - notch or cup and apply Ammate crystals into the cup, 1.2 pounds crystals per acre; plot 4 - frill and apply 2,4,5-T Esteron spray (1 part material per 24 parts diesel oil); plot 5 - basal spray of Esteron 2,4,5-T (1 part Esteron to 24 parts diesel oil); plot 6 - frill and apply 2,4-D spray (1 part material to 16 parts diesel oil); plot 7 - frill and apply mixture of 2,4,5-T and 2,4-D (brushkiller) spray (1 part material to 16 parts diesel oil); plot 8 - basal spray of 2,4,5-T and 2,4-D mixture (brushkiller) spray (1 part material to 16 parts diesel oil). The applications are at rather heavy rates but are the recommendations of the manufacturer of the herbicides.

The frilling consisted of making a single line of ax cuts around the tree trunks. The notching or cupping consisted of taking out chips of the bark at approximately 6-inch spacing around the tree. All frills, notches and girdle work was at a point approximately 30 inches above the ground. The basal spray was applied from the ground line up to about 24 inches. The plot layout for Experiment A is shown in Figure 8.

On these plots the number of trees by species and diameter class, the

Figure 8.—Experiment A - Plot Layout for Studying Several Chemicals As a Means of Killing Volunteer Trees on Strip-Mine Pasture Lands

Plot 2 1 gallon solution for 60 trees	Plot 7 1 gallon solution for 50 trees
Plot 4 1 gallon material for 62 trees	Plot 1 Girdle
Plot 5 3.4 gallons on 71 trees	Plot 8 3½ gallons on 86 plus 13 trees
Plot 6 1 gallon solution on 51 trees	
Plot 3 6 pounds crystals on 80 trees	

Plot size ½ acre
104.35 feet x 208.71 fee

8 plots

Plot	Treatment	Trees per plot (½ A.)	Labor Min.
1	Girdle	66	105
2	Frill and Ammate spray	60	80
3	Notch or cup and Ammate crystals	80	79
4	Frill and 2,4,5-T spray	62	72
5	Basal spray or 2,4,5-T	71	40
6	Frill and 2,4-D spray	51	70
7	Frill and brush killer spray	50	52
8	Basal spray of brush killer	86	47
	Average	65.75 per ½ A. or 132 trees per A.	

Date of application - July 24-26, 1951

quantities of material used and the actual time required in applying the materials were recorded. This data provides a basis for calculation of labor and material costs per acre as well as the ultimate determination of effectiveness of the several treatments. The species and number of trees found on the eight plots are shown in composite form in Table 18. On the 4 acres there were 526 trees of which 68 percent or 357 were cottonwood, with over one-half of the cottonwood falling in the 6, 8 and 10-inch classes. The average diameter was 8.42 inches. Elm, willow and sycamore were next most numerous in the order listed. These were smaller trees, however, with the majority of the trees in the 2 and 4-inch classes.

Upon inspection of these plots on August 3, 1951, it was noted that many of the tree leaves had turned completely brown on the plots where 2,4,5-T and 2,4-D - 2,4,5-T mixture had been used, both on frilled and basal spray treatments. Because of this surprising and drastic apparent killing effect, it was decided to study the effect of lower concentration of these materials as shown in Experiment B. Final results of these treatments, however, cannot be made until the growing season of 1952.

Table 18.--Composite Table Listing the Species and Diameter of Trees Found in Experiment A (Tree Killing Plots, ½-Acre Plots)

	Average diameter	2	4	6	8	10	12	14	16		Total number
	in.	in.	in.	in.	in.	in.	in.	in.	in.	pct.	
Cottonwood	8.42	14	55	56	77	79	40	19	17	68	357
Elm	3.48	43	7	3	5	2	2	0	0	12	62
Sycamore	4.75	11	13	2	6	5	0	0	0	7	37
Box Elder	5.12	8	3	0	1	1	3	0	0	3	16
Willow	2.36	43	5	2	0	0	0	0	0	10	50
Crataegus (Hawthorn)	2.0	2	0	0	0	0	0	0	0	trace	2
Wild Plum	2.0	2	0	0	0	0	0	0	0	trace	2

EXPERIMENT B:

Early observations with the chemicals as reported in Experiment A revealed rather rapid apparent killing effects at the concentrations recommended by the manufacturer. This experiment was designed to study the effect of lower concentrations of 2,4,5-T and 2,4-D - 2,4,5-T mixture in oil and in water. Fourteen one-fourth acre plots were established near the Experiment A area. The plot design used in this study is shown in Figure 9.

On these plots the number of trees by species and diameter class was recorded. The amount of material applied to the number of trees was also noted. The species and number of trees found on the 14 plots are shown in composite form in Table 19. In this experiment a total of 403 trees were treated. Box elder and cottonwood were most numerous with 39 percent of the trees being box elder and 37 percent being cottonwood. The cottonwood was the largest tree with over one-half falling in the 6, 8 and 10-inch classes. About 80 percent of the box elder were in the 4, 6 and 8-inch classes.

Table 19.—Composite Table of 14 Plants Listing the Species and Diameter of Trees Found in Experiment B

	2 in.	4 in.	6 in.	8 in.	19 in.	12 in.	14 in.	16 in.	Total
Cottonwood	8	18	15	28	33	19	13	15	149
Box Elder	18	35	43	49	10	3	0	0	158
Elm	25	7	12	4	2	1	0	1	52
Willow	15	2	0	0	0	0	0	0	17
Crataegos	22	0	0	0	0	0	0	0	22
Sycamore	1	1	0	1	0	0	0	0	3
Ash	1	0	0	0	0	0	0	0	1
Peach	1	0	0	0	0	0	0	0	1
									403

Figure 9.—Experiment B - Variations in Concentration and Application of 2,4-D, 2,4,5-T and 2,4-D - 2,4,5-T Mixtures in the Killing of Volunteer Trees Growing on Established Strip-Mine Pastures

104.35

104.35

Plot 14	Plot 1
Plot 13	Plot 2
Plot 12	Plot 3
Plot 11	Plot 4
Plot 10	Plot 5
Plot 9	Plot 6
Plot 8	Plot 7

Plot size - $\frac{1}{4}$ acre
(104.35 feet x 104.35 feet)
14 plots

Treatment and concentration		No. of trees
Frill and spray 2,4,5-T and water		
Plot 1	ratio - 1:96	30
2	1:72	32
3	1:48	38
4	1:24	23
Frill and spray 2,4,5-T and diesel oil		
Plot 5	ratio - 1:96	20
6	1:72	25
7	1:48	25
Basal spray 2,4,5-T and diesel oil		
Plot 8	ratio - 1:60	37
9	1:48	26
10	1:36	33
Basal spray brush killer and diesel oil		
Plot 11	ratio - 1:60	28
12	1:48	25
13	1:36	31
Basal spray 2,4-D and diesel oil		
Plot 14	ratio - 1:48	26
Total number of trees		399
	Average	28.5

28.5 x 4 = 114 trees per acre

August 8-9, 1951

A tabulation of all the treatments used, the amount of material applied, the labor required and the total cost of the several chemicals is presented in Table 20. The total cost ranged from \$2.58 to \$4.86 per acre. The most expensive treatment was a mixture of 2,4-D - 2,4,5-T applied as a basal spray in diesel oil at a 1:16 concentration. The total cost was \$4.86 per acre. On the basis of this study the labor required to apply the spray as a basal application was about $1\frac{1}{2}$ hours per acre while the girdling of the trees required about $3\frac{1}{2}$ hours per acre. While the results of the treatments will not be known until the next growing season, it appears from this study and recommendations made by the Illinois Agricultural Experiment Station (6) that a mixture of 2,4-D and 2,4,5-T in a mixture of oil and water applied as a basal spray will be most practical from the labor and total cost standpoint.

Utilization of Strip-Mined Lands:

The utilization of a strip-mined area is dependent upon several factors. From rough pasture lands the returns are dependent upon the gains made by the price received for the livestock that graze the area. Such areas can be utilized by cattle, sheep and hogs. Graded or leveled areas may be used for grain and hay production as well as grazing. Therefore, the returns from graded areas would be affected by the yield and price received for the grain and hay as well as the price of the livestock.

More mined acres are being used each year. According to the Illinois Coal Strippers Association at the present time, January 1952, about 54,000 acres have been strip-mined in Illinois. Approximately 35,000 acres or 64 percent have had some reclamation work done on them. Twelve thousand acres have been reforested with 12,000,000 trees and another 2,500 acres have been covered by volunteer tree growth. Sixteen thousand acres have been seeded to grasses and legumes for pasture

Table 20.--Tabulation Showing Chemicals Used, Concentration and Method of Application and Total Cost of Treatment of the Tree-Killing Experiment

Number of plots and experiment number	Herbicide	Method of application	Concentration ratio water	Concentration ratio diesel oil	Material used per acre amount	Material used per acre cost[a]	Labor used per acre man hours		Labor used per acre cost[b]	Total cost
					gal.		hr.	min.		
2-A	Ammate	frill	1#/gal.		2	$ .46*/	2	20	$2.33	$2.79
3-A	Ammate	cups	crystal form		1.2 lb.	.28	2	38	2.63	2.91
4-A	2,4,5-T	frill		1:24	2	1.31*/	2	20	2.33	3.64
7-B	2,4,5-T	frill		1:48	2	.77	2	20	2.33	3.10
6-B	2,4,5-T	frill		1:72	2	.59	2	20	2.33	2.92
5-B	2,4,5-T	frill		1:96	2	.51	2	20	2.33	2.84
5-A	2,4,5-T	basal		1:24	5	3.26	1	25	1.42	4.68
10-B	2,4,5-T	basal		1:36	5	2.38	1	25	1.42	3.80
9-B	2,4,5-T	basal		1:48	5	1.93	1	25	1.42	3.35
8-B	2,4,5-T	basal		1:60	5	1.67	1	25	1.42	3.09
7-A	2,4,5-T + 2,4-D[c]	frill		1:16	2	1.38*/	2	20	2.33	3.71
8-A	2,4,5-T + 2,4-D	basal		1:16	5	3.44	1	25	1.42	4.86
13-B	2,4,5-T + 2,4-D	basal		1:36	5	1.86	1	25	1.42	3.28
12-B	2,4,5-T + 2,4-D	basal		1:48	5	1.54	1	25	1.42	2.96
11-B	2,4,5-T + 2,4-D	basal		1:60	5	1.36	1	25	1.42	2.78
4-B	2,4,5-T	frill	1:24		2	1.07	2	20	2.33	3.40
3-B	2,4,5-T	frill	1:48		2	.53	2	20	2.33	2.86
2-B	2,4,5-T	frill	1:72		2	.35	2	20	2.33	2.68
1-B	2,4,5-T	frill	1:96		2	.27	2	20	2.33	2.60
6-A	2,4-D[d]	frill		1:16	2	.91*/	2	20	2.33	3.24
14-B	2,4-D	basal		1:48	5	1.16	1	25	1.42	2.58
1-A	none	girdle					3	30	3.50	3.50

a/Cost figured on following basis:
*/Ammate at 23 cents per pound; */Estron 2,4,5-T in 5 gallon lots at $12.80 per gallon; diesel oil at 12 cents per gallon; */2,4,5-T plus 2,4-D "Brushkiller" at $9.10 per gallon; diesel oil at 12 cents per gallon; */2,4-D at $5.40 per gallon in 5 gallon lots.

b/Labor cost at $1.00 per hour.

c/3.65 pounds acid equivalent per gallon except 7-A which contained 2 pounds acid per gallon.

d/Weed - No More.

development. Of this 16,000 acres, 11,000 acres are now being actively used for pasture, hay production, small grains or orchards. Thirty-five different farm units are utilizing the 11,000 acres

DISSEMINATION OF INFORMATION:

The unbiased dissemination of facts obtained in this study is a phase that deserves considerable effort. Education is probably the best method of getting a good reclamation program. The educational job in this case is twofold. First the strip-mine operators and second the public need to be convinced of the potential value of the stripped-over lands and that the raw land is not necessarily forever a wasteland.

Information concerning the findings of the strip-mine project has been disseminated through two methods. Copies of the annual report have been sent to various libraries, farm management companies and individuals who have expressed interest. It is of interest to note that copies have been sent to Department of Agriculture libraries in England and Canada as well as the Library of Congress in Washington and to several state libraries.

During the past year the strip-mine reclamation project has been discussed over Radio Station WILL. Two 10 to 15 minute discussions were broadcast to the listeners of the University radio programs.

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Outline

I. Soil investigations

- A. Mechanical analysis
- B. Soil analysis
  - (1) Boron added
- C. Organic matter of materials
- D. Adding limestone to acid stuff
- E. Total content of sulfur, etc.
- F. Grading of strip-mine land
  - (1) Table of availability
  - (2) Infiltration
  - (3) Slope measurement
- G. Microbiological studies

II. Forage species studies

- A. Species adaptation - aggressiveness of grass
  - (1) Alfalfa varieties studies
- B. Mixtures - kinds and effect as shown by botanical analysis
- C. Use of grain and seed crops
  - (1) Wheat
  - (2) Soybeans

III. Determination of forage yields and quality

- A. Forage yields
- B. Chemical composition
- C. Animal gains
  - (1) Sheep project
  - (2) Other cattle projects

IV. Economic interpretation

- A. Methods, cost and feasibility of species adaptation
- B. Accessibility and management after establishment
  - (1) Tree killing study
- C. Utilization of mined land

V. Dissemination of information

AFG:mlm
2-29-52

THE POTENTIALITIES OF REVEGETATING AND UTILIZING AGRONOMIC SPECIES ON STRIP MINED AREAS IN ILLINOIS

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A PROGRESS REPORT

COVERING THE SIXTH YEAR OF WORK ON A COOPERATIVE INVESTIGATION

CONDUCTED BY

UNIVERSITY OF ILLINOIS, AGRICULTURAL EXPERIMENT STATION

AND

ILLINOIS COAL STRIPPERS ASSOCIATION

NOTE

The agreement covering this investigation provides that: – "No account of a co-operative research project shall be published by the sponsor or by any other agency, except upon approval of the division of the University, or head of the department in which the work is being done."

Permission for the reproduction of this report has been granted with the understanding that it is to be released for the confidential information of members of Illinois Coal Strippers Association only, and not to be quoted or released for publication.

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A. J. CHRISTIANSEN
SECRETARY-TREASURER

FOREWORD

To Members of Illinois Coal Strippers Association

Gentlemen:

On February 1, 1947, Illinois Coal Strippers Association entered into an agreement with the Agricultural Experiment Station, University of Illinois, covering a project of cooperative research into the possibilities of revegetating and utilizing grasses and legumes on strip mined areas for stock range and other purposes.

This project was originally set up on an estimate that it would require five years of research in order to arrive at sound conclusions. It has, however, been extended for three more years and is now entering upon its seventh year. A progress report covering the first year of operation was issued on March 19, 1948 dealing principally with the proposed scope and plan of attack on the problem; a survey of spoil bank soils found throughout the state, and preliminary reports on a number of seeding projects. The second report was issued on March 15, 1949; the third report was issued on March 6, 1950; the fourth report was issued on March 1, 1951, and the fifth report was issued on April 1, 1952, presenting further information on spoil bank soil materials, and comparisons of such materials with surface soils found on adjoining land; the adaptation of various forage species to spoil bank soils; the results of preliminary studies of comparative gains made by animals pastured on spoil banks with those pastured on undisturbed blue grass and highly improved grass-legume pasture and the utilization of stripped land for pasture.

The report here presented covers the sixth year of operation. A consolidated final report, covering the first five years of the program is being printed as a bulletin of the University of Illinois Agricultural Experiment Station and should be available in the near future.

The studies to be made during the three year period will carry on the uncompleted work of the present research program and, in addition, will include several other phases of the strip mining problems dealing with grading, types of overburden, compaction, drainage, organic matter content, pasture carrying capacities, pasture management, weed and brush control, etc., and a report will be issued each year as the program progresses.

A J Christiansen
Secretary

March 25, 1953

AGRONOMY PROJECT

NUMBER: 1003 - Sixth Annual Report.

TITLE: Agronomic Land Use Research on the Mined Areas of the Stripped Coal Lands of Illinois.

OBJECT: The objectives of the project are to investigate the potentialities of revegetating and utilizing agronomic species on the strip-mined areas in Illinois.

LEADERS: A. L. Lang, J. A. Jackobs, J. N. Spaeth, and R. R. Snapp.

Advisory Committee:

Dean R. R. Hudelson
M. B. Russell
F. C. Bauer
J. C. Hackleman
J. N. Spaeth
A. J. Christiansen
Louis S. Weber

Agronomist - Edward A. Thurn

AGRONOMIC LAND USE RESEARCH ON THE MINED AREAS OF THE STRIPPED COAL LANDS OF ILLINOIS

by Edward A. Thurn[1]

The sixth annual report of progress on Agronomy Project 1003, covering the investigations of the potentialities of revegetating strip-mine lands with agronomic crops is herewith presented. This is a cooperative research project of the University of Illinois Agricultural Experiment Station and the Illinois Coal Strippers Association.

The sixth annual report covers the first year of a new three-year project designed to study basic principles of agronomic species on graded strip-mined land. Included in this report is a study of some physical and chemical properties on graded strip-mine land. The research of the previous five years was primarily devoted to the general development of the strip-mined areas. The research for the past year has been confined to graded areas primarily in western Illinois, and has been limited to fewer areas so that more detailed information could be obtained.

The author acknowledges the assistance of Mr. L. S. Weber, Land Use Engineer, Illinois Coal Strippers Association. Without his cooperation many of the research plots could not have been established. Also grateful acknowledgment is given Mr. Alten F. Grandt, Midland Electric Coal Corporation, for his cooperation and his technical experience in the strip-mine areas and to Dr. R. S. Stauffer, Associate Professor in Soil Physics, for his guidance and suggestions of the work plan.

In the past six years, experimental research has been carried on at

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[1] Assistant, Soil Fertility, Department of Agronomy, University of Illinois, Agricultural Experiment Station, Urbana.

25 different locations in 14 counties. Figure 1 shows the general location where these plots have been established.

INVESTIGATIONS OF PHYSICAL AND CHEMICAL PROPERTIES OF THE SOIL

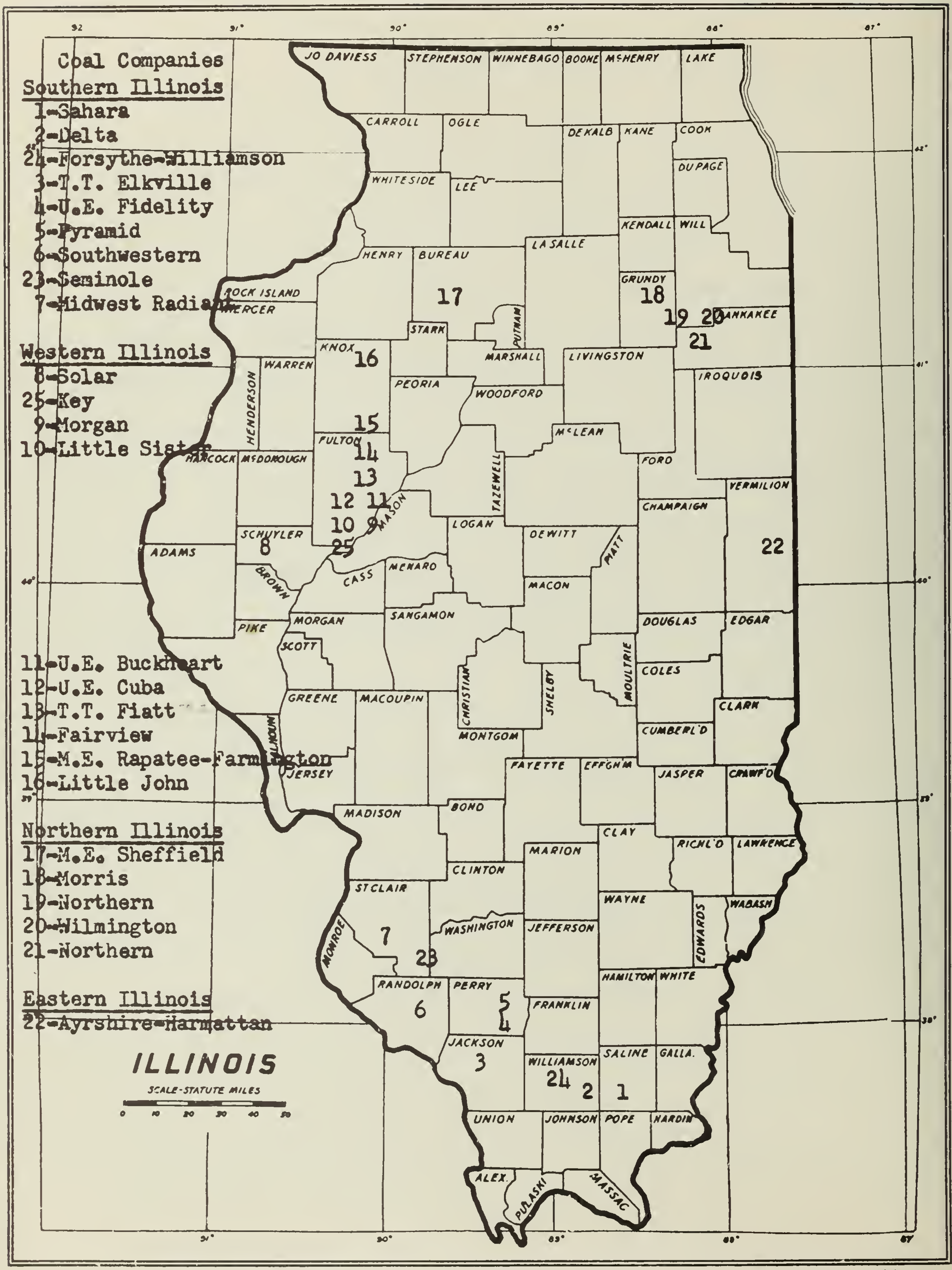
As of December 31, 1952, 1,648 soil samples have been collected from the experimental plot areas and all have been tested by the University of Illinois Soil Testing Laboratory. Table 1 shows the average amounts of available plant nutrients in the soil. The over-all average of these tests shows an acidity range in pH of 2.1 to 8.5, with 75 percent of these samples ranging in pH from 5.7 to 7.8. The average available phosphorus is 136 pounds per acre, and the available potassium is 169 pounds per acre. Two hundred and seven soil samples were taken and tested in 1952. These samples did not vary from the over-all average any appreciable amount.

In addition to the samples taken from the plot areas over 450 field samples have been taken. The results obtained are very similar to those obtained from the plot areas.

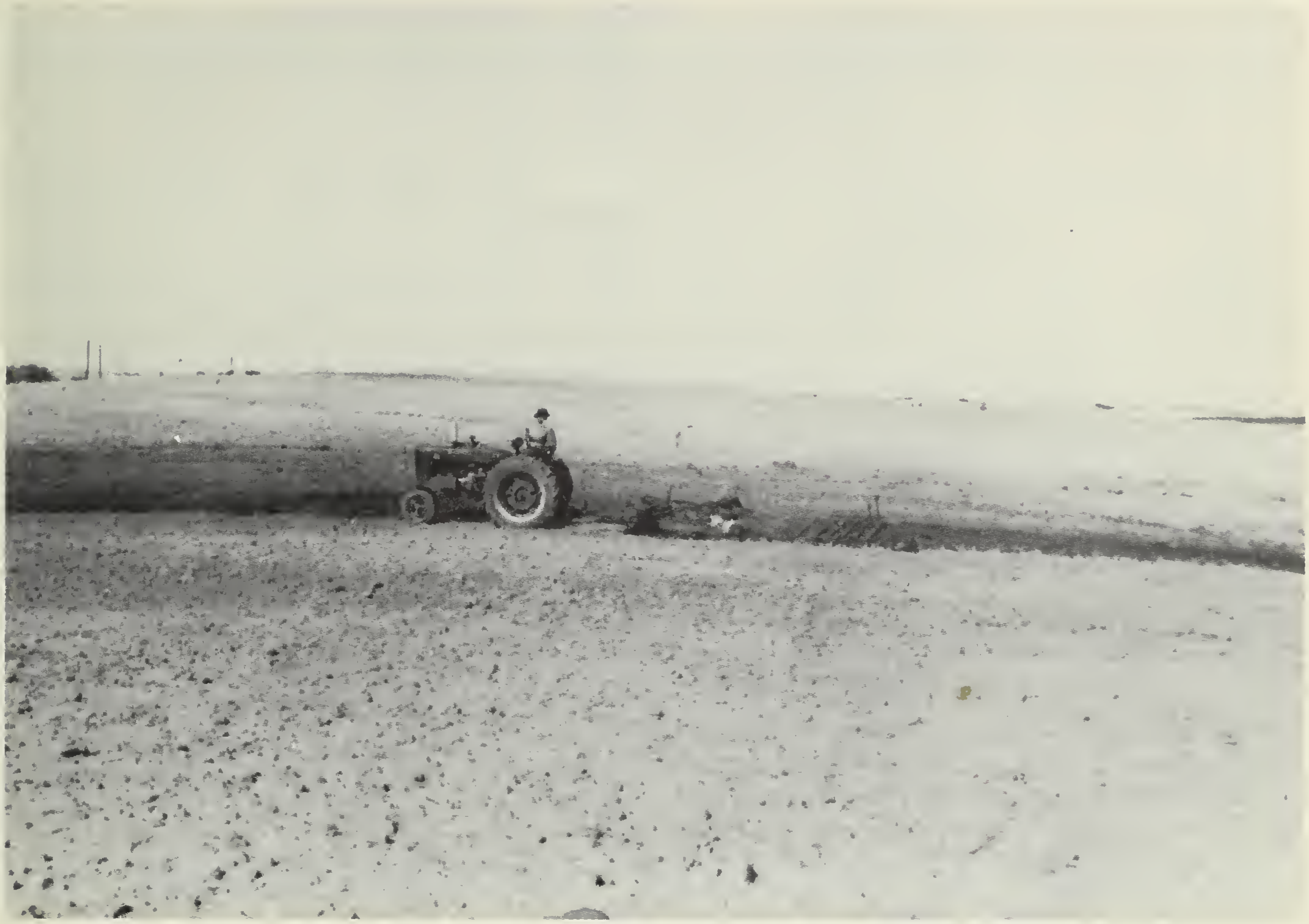
Most of the soil tests taken in 1952 were from graded areas (Fig. 2). As on ungraded spoils, wide variations frequently occur within small areas. But in spite of these variations it is of primary importance to thoroughly sample and test the soil of an area to determine its potential possibilities.

One of the essential elements for good forage growth is boron. It is a trace element which has received very little attention. However, legumes, especially alfalfa, are very sensitive to a boron deficiency. The fifth annual report gives the boron content as being very high. Samples taken this year in the same general area give only a medium test. The results, which were analyzed by the Soil Testing Laboratory at the University of Illinois, are listed in Table 2.

AGRONOMY DEPARTMENT, UNIVERSITY OF ILLINOIS, URBANA



Location of Experimental Plots on Strip-Mined Coal Lands in Illinois
(Fig. 1)



Foreground, freshly leveled area being prepared for a new seeding. Background, unleveled spoils. (Fig. 2)

Table 1.--Soil Test Analysis of Spoil Bank Material

Plot location	County	Number of samples	Acidity pH range L	Acidity pH range H[a]	pH range of 75 per-cent samples L	pH range of 75 per-cent samples H	Phos-phorus average lb.[b]	Potas-sium average lb.[b]
Southern Illinois								
Sahara	Saline	54	2.5	7.0	2.9	6.0	90	169
Delta	Williamson	65	3.1	8.2	4.7	7.9	92	134
Forsythe-Williamson	Williamson	23	2.5	8.2	4.9	7.5	178	169
Truax, Elkville	Jackson	55	3.4	7.8	5.0	7.4	117	173
U.E. Fidelity	Perry	89	2.3	8.3	3.9	7.9	151	206
Pyramid	Perry	65	4.0	8.2	6.6	7.9	93	160
Southwestern	Randolph	34	4.9	7.8	6.7	7.7	82	138
Seminole	St. Clair	10	7.2	7.7	7.4	7.7	126	168
Midwest Radiant	St. Clair	175	4.8	8.5	6.2	8.2	116	131
Subtotal and averages		568	2.3	8.5	4.9	7.9	115	157
Western Illinois								
Solar	Schuyler	12	4.4	7.6	6.5	7.2	171	224
Key	Fulton	16	6.9	8.0	7.3	7.9	107	103
Morgan	Fulton	15	6.5	7.8	6.7	7.7	185	216
Little Sister	Fulton	49	6.9	8.0	7.2	7.9	169	189
U.E. Buckhart	Fulton	48	6.9	8.1	7.3	7.9	125	133
E.E. Buckhart	Cuba	48	6.7	7.8	7.2	7.7	150	160
T.T. Fiatt	Fulton	150	6.4	8.3	7.4	8.0	160	158
Fairview	Fulton	54	2.7	7.9	6.2	7.6	143	172
Midland	Fulton-Knox	237	5.5	8.2	7.0	7.8	159	167
Little John	Knox	87	2.9	8.3	4.6	7.9	174	192
M.E. Atkinson	Henry	38	6.9	7.7	7.0	7.5	174	188
Pioneer	Peoria	16	2.7	7.7	6.8	7.6	165	
Subtotal and averages		770	2.7	8.3	7.0	7.9	158	169
Northern Illinois								
M.E. Sheffield	Bureau	89	6.1	8.1	7.1	7.8	152	217
Northern Illinois	Grundy-Will	87	2.4	8.1	3.0	7.6	142	192
Morris	Grundy	28	2.6	6.5	2.6	3.7	84	144
Wellington	Will	32	3.4	8.5	7.4	8.3	56	170
Northern Illinois	Kankakee	40	4.7	8.4	7.5	8.1	110	184
Subtotal and averages		276	2.4	8.5	3.2	7.9	125	191
Eastern Illinois								
Harmattan	Vermilion	34	2.1	8.1	6.7	7.5	59	192
Total and averages		1648	2.1	8.5	5.7	7.8	136	169

a/ Low and high pH

b/ P - 92 lb./A, high; K - 150-200 lb./A, high.

Table 2.--Special Soil Test Report for Available Boron

Company	County	pH	Available phosphorus	Available potassium	Available boron	Boron rating
Midland Rapatee	Knox	7.7	190	146	1.00	Medium
		7.3	208	300	1.25	Medium
T.T. Fiatt	Fulton	7.4	208	200	2.00	Medium
		7.3	208	158	1.25	Medium
Little Sister	Fulton	7.7	159	140	1.25	Medium
		7.4	200	235	1.00	Medium
Midland	Fulton	7.2	156	152	1.25	Medium
		7.3	123	152	1.25	Medium

There are many factors that could be in part responsible for this rapid change in boron content. First and probably the most important factor is leaching. Boron is a mobile ion. This ion is similar to nitrogen, in that it moves freely in soil solution. Any mobile ion is subject to severe leaching, especially when the quantity is high in the soil. This does not mean, however, that boron will be deficient in the near future. Crop removal also depletes the available boron in the soil but it is not normally removed very rapidly by cropping. Very few boron analyses have been made, and for this reason, the above data may not give an accurate representation of the spoil banks. Although the soil tests have shown a range in available boron from medium to very high, no plant toxicity or deficiency has been observed in the field. At this time there is no concrete evidence as to why there is such a wide variation of boron in the soil material.

Mechanical Analysis

Mechanical analysis, (1) or the measurement of soil particle size, is very important in determining the future potential of the spoil banks. One can see the rock, shale, and some sand. However, in respect to plant production,

the smaller particles are of greater importance. This analysis determines the quantity, in percent by weight, of sand, silt, and clay. This size distribution was obtained by analyzing the less than 2 mm. fraction of the soil material. The particle sizes of the above classifications are: sand - 2 mm. to 0.05 mm., silt - 0.05 to 0.002 mm., and clay 0.002 mm. and less. Table 3 gives the particle size for some graded areas in western Illinois.

Table 3.--Mechanical Analysis of Strip-Mine Soil Materials on Graded Areas[a]

Company	County	Sand 2 mm. to 0.05 mm.	Silt 0.05 mm. to 0.002 mm.	Clay 0.002 mm. and less	Soil class[b]
Somers pasture	Fulton	32.3	45.7	22.0	Loam
Little Sister	Fulton	15.2	54.8	30.0	Silty clay loam
Fairview	Fulton	11.7	43.5	44.8	Silty clay
Midland	Fulton	12.4	53.8	33.8	Silty clay loam
T.T. Fiatt	Fulton	20.4	43.8	35.8	Clay loam
U.E. Buckhart	Fulton	14.4	54.8	30.8	Silty clay loam
Midland	Knox	17.9	46.4	35.3	Silty clay loam
Fairview	Fulton	19.0	38.1	42.9	Clay

[a] The results in this table are composite samples from five sample areas.

[b] Based on texture.

There is no significant difference in the mechanical analysis of graded and ungraded areas. A farm soil having a classification of silt loam, which is a very common soil class, has an approximate range in particle size of 10 to 20 percent sand, 50 to 60 percent silt, and 20 to 30 percent clay. Most of the strip-mined land contains slightly more clay than this.

The small particles, or clay, are very important in that they are the main storehouse for plant nutrients. Clay particles are directly related to the capacity of a soil to supply nutrients to the plants. However, a soil can be too high in clay causing undesirable physical conditions. Too much clay can cause high plasticity, low aeration, high rate of compaction, and low

permeability. The water-holding capacity of a soil is determined by the amount of clay particles and the organic matter content. Since organic matter is deficient in the spoil banks, clay particles play an important role in water-holding capacity.

Mechanical analyses of the different strata in the high wall are listed in Table 4. These analyses illustrate the particle size of the material in the different strata. Further information will be submitted later in the paper.

Permeability and Physical Studies

Prior to grading the use of spoil bank areas is limited primarily to forestry, grazing, and recreation. After grading, when farm machinery can be used, crop land becomes a possibility. When the spoil banks are graded, and a more diversified utilization is possible, physical conditions become more important. Drainage, permeability, compaction, and puddling undergo changes in the process of leveling.

Leveling of spoil banks and vegetative growth causes a change in permeability of the soil material. On unleveled areas, where the land was bare and the material was a silty clay texture, the percolation rate was 9.29 inches of water per hour. On similar areas covered by vegetation for years, the rate was 13.57 inches per hour (2). These rates are classified as rapid and very rapid, respectively, by the Soil Conservation Service. Table 5 gives the results obtained in western Illinois on some of the leveled research plots.

The percolation rates given in Table 5 are much lower than results previously mentioned on similar but unleveled spoils. Apparently leveling reduces the rate of percolation, which is due to compaction during leveling and perhaps to some extent to settling.

Table 4.--Mechanical Analysis of Highwall Strata

Company	Strata	Sand	Silt	Clay	Soil class
	Topsoil	8.6	60.0	31.4	Silty clay loam
Midland	Lower Peorian loess	1.0	72.8	26.2	Silt loam
Electric	Sangamon loess	5.0	58.6	36.4	Silty clay loam
Fulton	Glacial till	11.2	64.4	24.4	Silt loam
county	Yellow shale	16.6	46.0	37.4	Silty clay loam
	Blue shale	14.8	53.2	32.0	Silty clay loam
	Topsoil	5.6	62.4	32.0	Silty clay loam
Fairview	Lower Peorian loess	....	72.4	27.6	Silty clay loam
Fulton	Sangamon loess	9.8	47.6	42.6	Silty clay
county	Glacial till	45.4	25.0	29.6	Sandy clay loam
	Yellow shale	26.4	45.8	27.8	Clay loam
	Grey shale	....	62.4	37.6	Silty clay loam
	Topsoil	5.4	59.0	35.6	Silty clay loam
Truax-	Lower Peorian loess	13.9	60.0	26.1	Silt loam
Traer	Sangamon loess	26.8	39.4	33.8	Clay loam
Fulton	Glacial till	19.4	33.8	36.8	Clay
county	Grey shale	....	37.2	62.8	Clay
	Blue shale	....	76.0	24.0	Silt loam
	Topsoil	7.6	69.6	22.8	Silt loam
Little	Lower Peorian loess	3.8	61.2	35.0	Silty clay loam
Sister	Sangamon loess	....	81.0	19.0	Silt loam
Fulton	Glacial till	21.8	33.6	34.6	Clay
county	Yellow shale	7.6	43.4	49.0	Silty clay
	Blue shale	.2	32.8	67.0	Clay
	Topsoil	7.4	71.6	21.0	Silt loam
Midwest	Lower Peorian loess	14.8	68.8	16.4	Silt loam
Radiant	Sangamon loess	6.8	71.2	22.0	Silt loam
St. Clair	Glacial till	32.2	39.6	28.2	Loam
county	Grey shale	17.6	52.5	29.9	Silty clay loam
	Topsoil	6.4	78.4	15.2	Silt loam
	Lower Peorian loess	16.6	54.4	28.6	Silty clay loam
Seminole	Glacial till	33.8	33.2	33.0	Clay loam
St. Clair	Yellow shale	20.4	71.2	12.6	Silt loam
county	Grey shale	1.8	46.6	51.6	Silty clay
	Black shale	1.2	45.6	53.2	Silty clay
U.E.	Topsoil	11.4	75.3	13.3	Silt loam
Fidelity	Lower Peorian loess	9.6	64.8	25.6	Silt loam
Perry	Yellow shale	4.2	48.6	47.2	Silty clay
county	Grey shale	21.6	44.4	34.0	Clay loam
	Topsoil	5.4	71.0	23.6	Silt loam
Southwestern	Lower Peorian loess	37.2	35.6	27.2	Clay loam
Randolph	Glacial till	8.2	62.2	29.6	Silty clay loam

Table 5.--Percolation Rate, Pore Space, and Volume Weight of Leveled Areas in Western Illinois[a]

Company	County	Depth of sample	Vol. wt.	Percolation	Total pore space	Capillary pore space	Noncapillary pore space
		in.		in./hr.			
Midland[b]	Knox	0 to 3	1.37	1.52	47.8	39.2	8.5
		9 to 12	1.49	.17	45.0	40.3	4.7
U.E. Buckhart[c]	Fulton	0 to 3	1.56	.69	42.0	37.0	5.0
		9 to 12	1.49	.37	45.5	38.8	6.9
Midland[d]	Fulton	0 to 3	1.34	.26	45.5	38.3	7.2
		9 to 12	1.56	.15	41.8	38.9	2.8
T.T. Fiatt[e]	Fulton	0 to 3	1.36	.21	47.5	39.3	8.2
		9 to 12	1.72	.24	37.9	35.8	2.1
Little Sister[f]	Fulton	0 to 3	1.31	1.50	47.4	37.3	10.1
		9 to 12	1.48	.12	43.7	41.6	2.1
Fairview[g]	Fulton	0 to 3	1.41	.53	48.4	39.9	7.9
		9 to 12	1.62	.57	41.2	36.9	5.9

[a] Each depth is an average of seven samples

[b] Leveled in 1947 - four years of alfalfa

[c] Leveled in 1950 - two years of alfalfa

[d] Leveled in 1952 - bare, planted to corn in 1952

[e] Leveled in 1952 - bare, planted to corn in 1952

[f] Box cut spoil leveled 1951 - volunteer growth

[g] Leveled 1951 - one year wheat

The following table has been set up by the Soil Conservation Service to classify the permeability rates in soils (3).

Permeability	Percolation inches per hour
Very slow	less than 0.05
Slow	0.05 to 0.20
Moderately slow	0.20 to 0.80
Moderate	0.80 to 2.50
Moderately rapid	2.50 to 5.00
Rapid	5.00 to 10.00
Very rapid	more than 10.00

The percolation on graded areas that have been analyzed ranges from slow to moderate which does not differ greatly from the percolation rates of most Illinois soils.

Table 5 shows higher volume weight in the 9 to 12 inch layer. The average of this layer is 1.56 compared to 1.39 for the 0 to 3 inch layer. Percolation average is 0.79 in the 0 to 3 inch layer compared to 0.27 in the 9 to 12 inch layer. Total pore space averages 46.4 and 42.5 in the 0 to 3 and 9 to 12 inch layers, respectively. Noncapillary pore space averages 7.8 and 4.1 in the 0 to 3 and 9 to 12 inch layer.

Total pore space is that part of the entire volume occupied by soil material not actually taken up by solid particles. As the clay content increases the total pore space generally increases, but the noncapillary pore space is likely to decrease. Pore space is of great importance since water and air relationships depend upon it. Soils with too low noncapillary porosity do not drain satisfactorily.

The total porosity is not so important for characterizing the structural properties of soils as is the relative distribution of the pore sizes (4). The noncapillary pore space is the sum of the volumes of the large pores, which will not hold water tightly by capillary. They are normally filled with air and are responsible for the air capacity and ready percolation of the water through the soil. Capillary porosity is the sum of the volumes of small pores that hold water by capillary. They are responsible for the water-holding capacity of the soil. A soil could have 50 percent or more total porosity with about equal amounts of capillary and noncapillary porosity (4). This distribution of total pore space might be found in very young or in very sandy soils. Many well drained soils in Illinois range from 3 to 8 percent noncapillary pore space (5).

The footnotes of Table 5 give the vegetative history of the individual fields. The following table gives the average of some of the physical measurements in Table 5 comparing alfalfa plots and bare corn plots.

All volume weights on alfalfa plots	1.48
All volume weights on bare plots	1.49
Percolation 0 to 3 inch layer alfalfa plots	1.11
Percolation 0 to 3 inch layer bare plots	.24
Percolation 9 to 12 inch layer alfalfa plots	.27
Percolation 9 to 12 inch layer bare plots	.20
Noncapillary pore space 0 to 3 inch layer alfalfa plots	6.8
Noncapillary pore space 0 to 3 inch layer bare plots	7.7
Noncapillary pore space 9 to 12 inch layer alfalfa plots	5.8
Noncapillary pore space 9 to 12 inch layer bare plots	2.5

Volume weight shows no difference between vegetative and bare areas. The surface layer under vegetation shows a significant difference in percolation. However, the 9 to 12 inch layer shows little increase for vegetation. Noncapillary pore space shows little variation in the surface layer between vegetated and bare areas. In the 9 to 12 inch layer, however, the noncapillary pore space is substantially higher in the vegetated plots.

The samples for this study were taken by the 3-inch core method (6). Some difficulty is encountered in sampling the material by this method because of its heterogeneous nature. However, it is the author's recommendation that this phase of the study should be continued.

CHARACTERISTICS OF THE STRATA IN THE HIGHWALL

The spoil banks are made up of a mixture of materials from different strata which occur above the coal. The percentage of each strata found in the upper portion of the spoil banks depends upon the thickness of the particular stratum as well as upon the method of mining. A study of the characteristics

of the strata and the proportion of each occurring in the overburden, coupled with the method of mining should furnish information on the amount of each strata occurring on or near the surface of the spoil banks. This information is of value in determining the best land use for these areas.

Samples of each stratum from the surface of the soil to the top of the coal were taken in order to make some chemical tests and also mechanical analyses. These samples were also studied in the greenhouse to determine their ability to support plant growth. The following table shows the classification of each stratum and its approximate thickness.

Classification	Depth ft.
Topsoil, normally plow depth	0-1.5
Lower Peorian loess	0-18[1]
Sangamon (Farmdale) loess	2-9
Glacial till	5-30
Yellow shale) Gray shale) variable depths Blue shale)	4-50
Rock	0-25

[1] This depth includes all Peorian loess

The thickness of the individual strata varies with the total depth of the overburden and also with location. As the overburden becomes thicker the shales generally become thicker. The upper strata also vary in thickness but to a lesser extent than the shales.

Table 6 illustrates the chemical analysis of the samples taken in the highwall.

Table 6.--Chemical Analyses of Samples From Individual Strata

Strata	pH acidity range		Available phosphorus		Available potassium
	L[c]	H[c]	P_1[a]	P_2[b]	
			lb./A.	lb./A.	lb./A.
Topsoil	5.0	7.0	15	22	215
Lower Peorian loess	5.2	7.7	27	140	209
Sangamon loess	7.0	7.9	14	104	180
Glacial till	4.4	7.9	8	87	188
Yellow shale	7.2	8.3	9	109	196
Gray shale	7.6	8.1	6	122	268
Blue shale[d]	7.3	8.3	7	200	304

[a] P_1 - exchangeable - readily available to the plant

[b] P_2 - total available phosphorus

[c] Low and high

[d] Unpublished data by G. Deithschman and J. W. Neckers (10)

The topsoil is usually leached of the more soluble constituents. This varies according to the previous management and fertilizer program. However, the surface soil material, which includes all the loess, is in general high in plant nutrients. The glacial till is variable in that the Illinoisan till is highly weathered and leached. The more recent Wisconsin till, which is not found south of Peoria county, is not so highly weathered. The shales are normally alkaline and high in phosphorus and potassium. The shale layers are very similar in characteristics except that the upper shales are more weathered which causes the variation in color. The above table indicates less phosphorus and potassium in the upper shales than in the lower shale.

The mechanical analysis of the highwall samples are illustrated in Table 7.

Table 7.--Mechanical Analysis of Strata in the Overburden[a]

Strata	Soil separates: Sand 2.0-.05 mm.	Silt .05-.002 mm.	Clay .002 mm. and finer	Soil class
Topsoil	7.4	68.4	24.4	Silt loam
Lower Peorian loess	12.4	59.5	27.8	Silty clay loam
Sangamon loess	10.9	60.7	28.4	Silty clay loam
Glacial till	25.3	40.5	31.3	Clay loam
Yellow shale	14.7	51.6	33.7	Silty clay loam
Gray shale	8.2	48.6	43.2	Silty clay
Blue shale	2.1	48.9	50.7	Silty clay

[a] Averages from Table 4

A mixture of the above strata makes up the material in the spoil banks. It cannot be foretold what percentage of each stratum will make up the mixture of the upper portion of the spoil, because the method of stripping is a factor in this determination. Good, productive soils usually contain a mixture of sand, silt, and clay. Those containing a relatively high percentage of silt and sand usually drain well and are well aerated. Such soils are less subject to puddling and compaction than those containing a high percentage of clay. On the other hand, soils containing a high proportion of clay are easily puddled and may become very compact and impervious to water unless managed so as to retain a granular structure. Clay particles are very small and plate or disk-like in shape and can be fitted very closely together, thus forming an impervio mass. This is what happens when clay soils are tilled too wet. Therefore, it is reasonable to assume that where shaly material makes up a considerable portic of the surface layer of spoil banks, great care must be exercised in working and leveling the material or a compact unproductive soil will result.

The clay mineral types in the shale are for the most part illite, kaolinite, and chlorite. The quantity of the different clay mineral types

vary widely within the state. Illite has been found in all of the shales. It will range from about 40 to 100 percent of the clay content. Kaolinite is usually found in southern Illinois and ranges from 0 to 40 percent. Chlorite usually ranges from 20 to 40 percent (7). The clay mineral illite is desirable in our Illinois soils. Kaolinite is not as desirable as illite, but this clay mineral can form good productive soils. Chlorite is the first of these minerals to break down, and it is not as important in soil formation.

The weathering or disintegration of the shales is for the most part very rapid. When placed in water, a 7-pound sample with a rock hardness of 2.0, completely broke down in 3 to 4 hours. It is noted in the field that the shales decompose very rapidly.

A study of the strata in the highwall was made in the greenhouse. Samples of each stratum were placed in gallon jars. Nitrogen was added to each jar at the rate of approximately 100 pounds of the element per acre. Alfalfa, ryegrass, and corn were planted. In all cases the alfalfa and ryegrass germinated. In five of the corn samples, the seed rotted before germination. Alfalfa did not continue to grow on samples with a low pH, but it did grow on the other samples. The ryegrass grew on all samples. Corn, however, was retarded in growth and the plants did not have a healthy appearance.

Figures 3 and 4 indicate that, in general, forage crops are more adaptable to the individual strata than corn. They also indicate that the percentage of each strata in the upper portion of the strip-mined lands are a factor in their potential productivity.

FORAGE CROPS

Legumes and grasses continue to be the principal crops best adapted to the spoil banks. Some crops are better adapted geographically than others. A seeding mixture of alfalfa, brome, and orchard grass appearsto give the best

Top soil

Lower Peorian loess

Glacial Till

Yellow shale

Grey shale

Blue shale

Fig. 3

Fig. 4 Corn growth on individual strata within the same highwall. The strata are from left to right top soil, lower Peorian loess, glacial till, yellow shale, grey shale, and blue shale.

results for western Illinois. Birdsfoot trefoil is well adapted, but it cannot withstand severe competition in pasture establishment. It has proven successful when seeded with red clover. The longevity of birdsfoot trefoil is its greatest attribute. Once established, it will compete with weeds and other undesirable plant species. Figure 5 shows a well established stand of birdsfoot trefoil. It is particularly good on unleveled areas because once established, it furnishes good pasture for many years. Ladino clover is very well adapted and it is very palatable and good animal gains can be made, but due to the possibility of bloat, it is not recommended in the above seed mixture. Fescue, bluegrass, and timothy are also well adapted.

Alfalfa, lespedeza, fescue (Ky. 31 and Alta), and orchard grass makes a good seed mixture for southern Illinois. Birdsfoot trefoil is also well adapted in this part of the state. Since southern Illinois has a longer growing season than the rest of the state, there is a possibility of year round grazing. The University of Illinois experiment station at Dixon Springs has carried out some research work on winter pastures. These experiments showed that a mixture of Ladino clover and fescue grass would maintain beef cows throughout the winter. These pastures were grazed from October to May. It was determined that $1\frac{1}{2}$ acres of pasture would maintain one beef cow. The only supplementary feed fed was hay when snow and ice prohibited grazing. These animals did not gain any weight during this grazing period, but neither did they show a loss. However, greater gains were made by these animals on the following spring and summer pasture than by animals wintered in a drylot.

Alfalfa variety studies were established by Grandt (8) in 1950 and 1951. Eleven varieties were established on graded areas in nine different locations. The object of this study was to determine what alfalfa variety or

Good stand of birdsfoot trefoil (Fig. 5)

varieties were best suited for the strip-mined areas. Due to reseeding, physical destruction, and grazing, only two locations are still intact.

The two plots studied this year were both seeded in the spring of 1951. Climatic conditions for the following winter were favorable for alfalfa winter survival. It will require many years to show which variety is best suited for the mined lands. Table 8 gives the plant survival and the 1951 winterkill, for plots in southern Illinois. Even though winter conditions were not severe, some varieties show a very high mortality rate. They consist mainly of nonhardy types. The varieties with high mortality rates are becoming infested with weeds, and it is expected that by next year these varieties will produce lower yields and lower quality hay. The varieties with a small amount of winterkill are well established with little or no infestation of weeds.

Table 8.--Plant Survival and 1951 Winterkill for Alfalfa Varieties in Southern Illinois

Variety	Number of live plants per sq. ft.	Death loss per sq. ft.
		perct.
Roswell	9	2.2
Buffalo	13	0
Kansas Common	11	1.4
Chilean	6	7.6
Hatch	10	1.9
India	5	24.8
Africa	3	37.2

Table 9 gives the average and individual alfalfa yields for southern and western Illinois. The average production for the different varieties shows no significant difference. The number of plants per square foot is in most cases quite high. Four alfalfa plants per square foot are adequate for good production, on highly fertile soil, as long as weeds can be controlled. Wilt resistant and winter-hardy varieties should continue to show good yields while

the other species not so well adapted will reduce yield.

Table 9.--1952 Average of Individual
Alfalfa Yields

Variety	Yield
Individual yields for southern Illinois	
	T./A.
Buffalo	1.9
Roswell	1.7
Hatch	1.6
Kansas Common	2.3
Chilean	1.8
Africa	1.4
India	1.6
Individual yields for western Illinois	
Buffalo	5.5
Roswell	5.5
Hatch	5.2
Chilean	5.2
Africa	5.2
India	5.7
Average yields for southern and western Illinois	
Buffalo	3.7
Roswell	3.6
Hatch	3.4
Chilean	3.5
Africa	3.3
India	3.7

The low yields in southern Illinois were primarily due to the very serious drouth. Only two cuttings were taken and the second cutting had suffered severely from lack of moisture. Previous data show that under normal climatic conditions, the southern Illinois spoil banks are quite capable of producing good quality, high yielding legumes and grasses.

In western Illinois the winter survival of the southern alfalfa species was very high. The lack of winterkill in western Illinois was probably due to climate and not to species. Since population, or thickness of stand,

was very similar for all varieties, a field observation showed little difference in growth. The yield of three cuttings of hay substantiates this observation. Samples were taken for the fourth cutting on October 8, 1952. This cutting yielded from 1.2 to 1.6 tons giving one variety a total yield of 7.2 tons for the season. The fourth cutting was not included in the year's average, because it is impractical to cut hay at this time. This would result in a lack of food reserve in the roots causing a high winter mortality rate and a reduced growth the following year.

Legume and grass plots have been established under different fertility rates to determine whether or not longevity and yields can be increased. Figure 7 describes a nitrogen study on alfalfa, brome, and birdsfoot trefoil. The series of fertility rates are set up in triplicate and the species are randomized. A blanket application of 300 pounds of 0-20-20 fertilizer was applied so that phosphorus and potassium would not be a limiting factor in plant growth. Variable rates of nitrogen were applied, see Figure 7, to determine what effects could be derived from nitrogen. These plots were seeded on April 11, 1952. Yields were not taken this year since the first season's growth was not adequate for yield determinations. Little or no difference was observed in thickness of stand in the fall of 1952 due to nitrogen.

Growth did show a response to nitrogen on bromegrass seeded without legumes. When grasses and legumes are seeded as a mixture, the grasses show a better growth than when seeded alone. For this reason the response of grass in the mixture to nitrogen fertilizer cannot be determined. Stand and yield determinations will be made in 1953, and at this time more information will be obtained.

Alfalfa establishment on graded area in western Illinois. (Fig. 6)

Figure 7.--Nitrogen Study on Legumes and Grass

Nitrogen pounds per acre

0	Alfalfa	120	Alfalfa	30	Birdsfoot trefoil
	Alfalfa-brome		Alfalfa-brome		B. trefoil-brome
	B. trefoil-brome		B. trefoil-brome		Alfalfa
	Birdsfoot trefoil		Birdsfoot trefoil		Alfalfa-brome
10	Alfalfa-brome	90	Alfalfa-brome	10	Birdsfoot trefoil
	Alfalfa		B. trefoil-brome		Alfalfa
	B. trefoil-brome		Birdsfoot trefoil		Alfalfa-brome
	Birdsfoot trefoil		Alfalfa		B. trefoil-brome
30	Alfalfa	60	B. trefoil-brome	0	Birdsfoot trefoil
	Birdsfoot trefoil		Alfalfa-brome		Alfalfa
	Alfalfa-brome		Alfalfa		Alfalfa-brome
	B. trefoil-brome		Birdsfoot trefoil		B. trefoil-brome
60	Birdsfoot trefoil	30	B. trefoil-brome	120	Alfalfa
	Alfalfa		Alfalfa-brome		Alfalfa-brome
	Alfalfa-brome		Birdsfoot trefoil		B. trefoil-brome
	B. trefoil-brome		Alfalfa		Birdsfoot trefoil
90	Alfalfa	10	Birdsfoot trefoil	90	Alfalfa
	Birdsfoot trefoil		B. trefoil-brome		Birdsfoot trefoil
	B. trefoil-brome		Alfalfa		Alfalfa-brome
	Alfalfa-brome		Alfalfa-brome		B. trefoil-brome
120	Birdsfoot trefoil	0	Birdsfoot trefoil	60	Alfalfa-brome
	B. trefoil-brome		B. trefoil-brome		Alfalfa
	Alfalfa-brome		Alfalfa-brome		B. trefoil-brome
	Alfalfa		Alfalfa		Birdsfoot trefoil

Figure 8 describes a fertility study to determine the plant growth response to nitrogen, phosphorus, and potassium.

Figure 8.--Fertility Study of Nitrogen, Phosphorus, and Potassium on Alfalfa and Birdsfoot Trefoil

0-0-0	8-8-8
8[a]-8[b]-0	8-0-8
0-8-0	8-0-0
0-0-8[c]	0-8-8
0-8-8	0-0-8
8-0-0	0-8-0
8-0-8	8-8-0
8-8-8	0-0-0

[a] Equivalent to 300 pounds of a 20 percent nitrogen fertilizer per acre.

[b] Equivalent to 300 pounds of superphosphate per acre.

[c] Equivalent to 100 pounds of muriate of potash per acre.

These plots were seeded on April 29, 1952. Yield and stand studies will be made in 1953. There was no apparent variation in growth in the first season due to fertilizer.

GRAIN CROPS

When spoil banks are graded there are more possibilities for utilization. Farm machinery can be used which makes the growing of grain crops possible. This in turn requires a crop rotation. On freshly leveled areas it appears now that it is advisable to grow grasses and legumes for some time before adopting a crop rotation. Just how long this interval of time should be is not known at present. A tentative long-time cropping plan should be made for each individual graded area and as more information is accumulated, changes in the planning can be made to fit the situation.

There are several reasons why grasses and legumes have a beneficial effect on freshly graded areas. These species provide a good environment for a rapid increase in bacteria. They tend to increase the degree of aggregation and stability in the soil. The organic matter formed in the soil by these species increases permeability which allows better drainage and aeration. A few years growth of legumes and grasses plan an important role in greatly reducing crusting and puddling. The root penetration is a means of opening up this soil material allowing a deeper water penetration.

Wheat, rye, and barley have proved successful in most instances when seeded immediately after leveling. It is possible to seed these species in the fall as a nurse crop for the spring seeded legumes and grasses. In this manner it is possible to produce a cash crop while establishing the legumes and grasses. It must be remembered that if the nurse crop is too successful, and therefore competitive to the grasses and legumes, the initial objective of establishing legumes and grasses will be defeated. The legumes and grasses can be seeded in the fall with the nurse crop, but due to the

Wheat yielding 30.5 bushels per acre on freshly graded strip-mined land in western Illinois. (Fig. 9)

Good stand of alfalfa immediately after the removal of wheat nurse crop.
(Fig. 10)

possibility of a crust forming on the soil which prevents the seedling from coming up, this procedure is not recommended. This crusting or compacting is primarily due to the lack of organic matter and poor soil structure. This situation is developed by the soil drying out after a heavy rainfall. If the seedlings break the surface before this happens, a good stand usually results.

Wheat yields taken from two areas in western Illinois yielded 19.1 bushels per acre and 30.5 bushels per acre. This average yield of 24.8 bushels per acre was grown under good climatic conditions. The alfalfa seeded in these areas shows an excellent stand when 19.1 bushels of wheat per acre were grown, but the area producing 30.5 bushels of wheat had a poor stand of alfalfa. These were not experimental plots and consisted of approximately 70 acres. The following wheat yields are an average for three years.

Table 10.--Average Wheat Yields for Strip-Mined Land

Year	Yield
	bu./A.
1949	24.5
1951	18.0
1952	24.8
Average	22.4

The wheat yielding 30.5 bushels per acre had a protein content of 12.4 percent and the weight was 62 pounds per bushel. These results show this wheat to be of high quality.

Soybeans were seeded in the spring of 1952 on a newly graded area. Figure 11 illustrates the fertilizer applied to this area. There was no noticeable difference in growth due to the above fertilizer applications. The manure plots were somewhat better, but in no case did the plants have a normal growth.

These plants did mature and form seed pods even though the average height of the plant was approximately 14 inches. These plants were affected by root rot caused by <u>Rhizoctonia</u> <u>solani</u>. This disease is not common in Illinois but is aggravated by cool, wet weather in the early spring (9). The root rot may have been in part responsible for poor growth, but other factors were also responsible. Yield data were not taken from these plots. The soybeans were plowed down and this area was seeded to fall alfalfa.

Figure 11.--Fertilizer Application on Soybean Plots

Check			
P[a]			
K[b]			
Calfide[c]			
Manure[d]			
PK			
	200[e]	100	0

[a] 400 pounds of superphosphate per acre.

[b] 150 pounds of muriate of potash per acre.

[c] 1,150 pounds per acre.

[d] 10 tons per acre

[e] Pounds of elemental nitrogen

Since corn is one of the better cash crops grown in Illinois, more work was done with this crop than with other cash crops on the graded areas. Six areas were planted in corn in 1952 producing an average yield of 43 bushels per acre. Two of these areas yielded no production and they are averaged into the above yield. The yields for the individual areas ranged from 0 to 86 bushels per acre. This wide range in yield can be explained in part by presenting the history of these areas.

In all cases the results from the soil tests indicated the pH, phosphorus, and potassium to be high and very high. In some instances, the areas were alkaline. The mines where the plots were established furnished machinery, fertilizer, seed, and much of the labor.

Three ½-acre plots were established on the Little Sister mine. Funk's Hybrid Seed Company furnished the seed and planted two of these areas. On one plot 800 pounds of an equivalent of 20-20-20 fertilizer were broadcast per acre and worked into the soil. Two hundred and forty pounds of 6-12-12 per acre were applied as starter fertilizer. This plot averaged 46 bushels per acre. The next plot received 500 pounds of 20-0-0, 250 pounds of 0-20-0, and 150 pounds of 0-0-60 fertilizer per acre broadcast. Again 240 pounds of 6-12-12 were used as a starter fertilizer. This plot produced an average of 53 bushels per acre. These spoil banks were leveled in 1950 and one years growth of Sudan grass had been grown on the area.

The third plot of this series was established on a box cut spoil that had been graded in 1950. The previous vegetation was volunteer growth which consisted mostly of weeds. This area had less rock and shale and more loess and till in the spoil bank mixture than average. The chemical analysis of this plot had a pH range of 7.3 to 7.7, an average available phosphorus reading of 183,

and a potassium reading of 174 pounds per acre. The yields and fertilizer application are illustrated in Figure 12.

Figure 12.--1952 Yield and Fertilizer Application on Corn Plots on the Little Sister Mine

Nitrogen	P[c]	O	K[d]	PK
Check	46.0[a]			
250[b]	76.3	75.1	94.9	58.7
160	46.6	47.6	48.7	83.1
80	80.1	98.2	108.7	63.7

[a] Corn yield per acre.

[b] Pounds of elemental nitrogen per acre.

[c] Equivalent of 300 pounds of superphosphate per acre.

[d] Equivalent of 100 pounds of muriate of potash per acre.

Poor corn growth on freshly graded areas. (Fig. 13)

The yield of the check plot with no fertilizer applied produced 46 bushels per acre. An analysis of the yield shows an increase for an application of nitrogen. The phosphorus and potassium plots with variable rates of nitrogen do not show any definite yield response. The individual yields under varied fertility rates are so variable that a specific response to the various fertilizers cannot be accurately determined from these data.

This variation in yield was due in part to some causes that are not as yet completely identified. When these corn plants were approximately 12 inches tall, the top growth developed symptoms that were similar to a phosphorus deficiency. These plants were analyzed in the laboratory and gave a high test for phosphorus, potassium, and magnesium. The plants were stunted in growth and many of the leaves were damaged. In about 10 days the plant overcame these symptoms and started to grow. During this period some of the plants were removed in order to observe root structure. The roots were strong and sturdy, and formed a good root system. However, the conditions mentioned above, weakened the corn plants. At a later date these plots were infested with the northern rootworm. This infestation was also found in surrounding fields. It is now known to what degree the rootworms reduced yield, but they did cause a reduction in root support and much of the corn was down at the time of harvest.

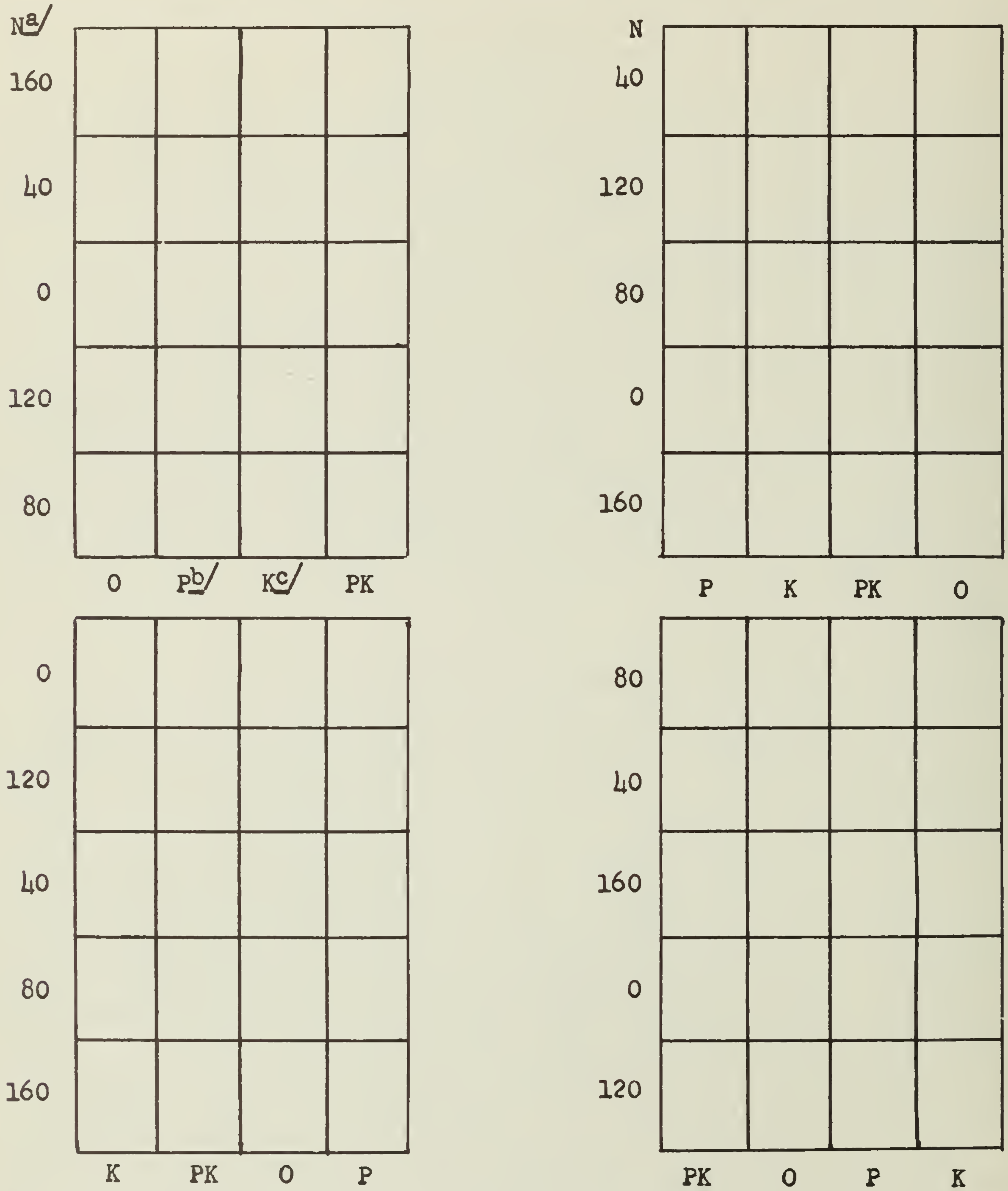
Two more areas were selected for corn plots. These were newly graded spoils with no previous vegetative growth. Fertilizer applications of many variations were applied. On the area established on the Truax-Traer mine at Fiatt, 10 tons of manure per acre were applied to one series of plots. These plots were crossed with variable rates of nitrogen. All of the plots in this area developed symptoms similar to the area on the Little Sister mine. This

Upper, corn growth after four years of legumes. Foreground freshly leveled spoils. Lower, close-up of the same field. (Fig. 14)

corn produced tassels and silks when the stalk was $3\frac{1}{2}$ to 4 feet tall, but there was no yield of grain. The manure plots were somewhat better than the other plots, but they did not mature adequately to develop grain. The soil conditioner, "Calfide", was applied as was nitrogen, phosphorus, and potassium. It was observed that, if anything, Calfide repressed plant growth. The other area, established on the Midland Electric mine produced results very similar to the previous plots. Sections of these plots were treated with the minor elements zinc, copper, boron, manganese, iron, and molybdenum. The amounts of these elements needed for plant growth are extremely small. An equivalent of 20 pounds per acre of each of these elements were sprayed on the corn foliage. No response was obtained by these applications, and it is probable that none of these elements was a factor in creating the above symptoms. All plots were treated with variable rates of nitrogen, phosphorus, and potassium. No corn was produced on any of these plots.

The last area where corn plots were established has a different background. This area was leveled in 1947. In 1948 one-half of the area was seeded to alfalfa and one-half to sweet clover. This alfalfa remained on the field with the exception of 1950 when a hay crop was removed. The alfalfa and sweet clover were plowed in the spring of 1952 and the area was planted to corn. Twenty variations of fertilizer were applied in quadruplicate making a total of 80 plots. This series of fertilizer application was randomized so that factors other than fertilizer could be reduced to a minimum. These plots are illustrated in Figure 15. The average number of corn plants per acre was 10,420. This population is a little low, and could be a factor in reducing production. The average yields of the replicates under different fertilizer applications are given in Table 11.

Figure 15.--Fertilizer Application on Corn



[a]N - pounds of elemental nitrogen per acre.

[b]P - the equivalent of 300 pounds of superphosphate per acre.

[c]K - the equivalent of 100 pounds of muriate of potash per acre.

Table 11.--Yields of Corn on Leveled Area in Western Illinois 1952

	P[a]	K[b]	PK	O	Average
	bu./A.	bu./A.	bu./A.	bu./A.	bu./A.
0	91.0[c]	82.2	84.1	92.5	87.5
40[d]	86.3	85.0	93.5	86.7	87.9
80	92.3	77.4	81.9	72.5	81.0
120	93.6	85.6	97.9	83.4	90.1
160	101.9	92.2	98.5	79.3	92.9
Average	93.0	84.5	91.2	82.9	

[a] 300 pounds of superphosphate per acre.

[b] 100 pounds of muriate of potash per acre.

[c] Average corn yield of three replications.

[d] Elemental form of nitrogen - pounds per acre.

The statistical analysis of these data shows no significant increase in yield when nitrogen was applied at the given rates. This means that the previous vegetation that was returned as green manure along with the root system of that vegetation accumulated enough nitrogen in the soil that the nitrogen was not a limiting factor in yield. When potassium fertilizer was added, there was no increase in yield. When phosphorus fertilizer was added, there was a significant increase in yield.

The pH of this soil material was 7.5. The available phosphorus reading was very high. As the pH increases the phosphorus equilibrium tends to move toward the easily acid soluble state causing the exchangeable or plant available phosphorus to be reduced. Since the soil test reads a given amount of acid soluble and exchangeable phosphorus, it is possible to get a high

reading under this condition, and not have a high plant availability. This could be a reason for the increase in yield when phosphorus fertilizer is applied. A complete analysis of the data shows no significant interaction between nitrogen and phosphorus when applied to the same plot. However, the heavier applications of nitrogen did cause some increase in yield even though it was not significant.

The increase in yield on the phosphorus fertilized plots over the nonphosphorus fertilized plots was 8.4 bushels per acre. These results are from only one area for one year, and more data must be accumulated before any accurate fertilizer recommendation can be made. It is questionable from the above data as to whether an application of phosphorus fertilizer is economical.

TREE KILLING EXPERIMENT

In 1951 tree killing experiments were initiated on strip-mine land. The fifth year progress report presented detailed information on the establishment of these experiments including plot layout, herbicides used, rates and methods of application, number of tree species by diameter, class, and cost studies. Final results of these experiments will be available after the 1953 growing season.

An interim inspection of Experiment A was made in July 1952, one year from the date of application. This experiment was designed to study eight different methods of killing trees on eight ½-acre plots. There was an average of 132 trees per acre consisting of 68 percent cottonwood, 12 percent elm, 10 percent willow, 7 percent sycamore, and 3 percent box elder. The cottonwood was also the largest specie in size with an average diameter of 8.4 inches and a maximum of 16 inches.

Table 12 gives the results observed after one year of this experiment.

Table 12.--Effect of Herbicide on Tree Growth One Year After Application

	Complete top kill Bark splitting Heavily defoliated Remaining leaves Completely brown	Partial top kill Various stages defoliation Leaf browning	No noticeable effect
	perct.	perct.	perct.
Plot 1-A check girdle only	38	13	49
Plot 2-A frill & ammate 1 lb. per gal. water	24	60	16
Plot 3-A cup & ammate crystals - .6 lb.	29	62	9
Plot 4-A frill & spray 2,4,5-T in oil 1:24	84	14	2
Plot 5-A basal spray 2,4,5-T 1:24 in oil	97	0	3
Plot 6-A frill & spray 2,4-D 1:16 in oil	69	31	0
Plot 7-A frill & spray brush killer 1:16 in oil	78	16	6
Plot 8-A basal spray brush killer 1:16 in oil	85	13	2

Ammate - ammonium sulfamate

2,4,5-T - esteron 2,4,5-trichlorophenoxyacetic acid, propylene glycol butyl ether ester 66 percent or 4 pounds acid per gallon.

2,4-D - isopropyl ester of 2,4-dichlorophenoxyacetic acid 44 percent or 3.3 pounds acid per gallon.

Brush killer - 2,4-dichlorophenoxyacetic acid 2 pounds per gallon and 2,4,5-trichlorophenoxyacetic acid propylene glycol butyl ether ester 2 pounds acid per gallon.

Plot No. 5 upon which a basal spray of 16 pounds a h g of 2,4,5-T[1] in diesel oil was applied gave the most spectacular results. This was closely followed by Plot No. 8 in which the method of application was also basal spray using the trade named herbicide "Brush Killer" a mixture of 2,4,5-T and 2,4-D[2] at the ratio of 1:16 in diesel oil.

It is expected as indicated that a high percentage of trees under all treatments will be killed. However, the time factor and rate of decay is significant. For example a large part of the foliage on Plot No. 5 was completely brown within 10 days of application; within six months, in many cases, the bark had split and begun to curl back from the base to the top of the tree. A brief inspection at 16 months showed that large limbs were falling and some of the smaller trees were down. The 3 percent reported in the column "No noticeable effect" for Plot No. 5 actually represents two elms in the 2-inch class. This may be the result of faulty application, since other elms in this size class were killed as well as one 4-inch elm, the largest on this particular plot. Elm has given every indication of being the most difficult species to kill of those tested.

Experiment B. which consists of 14 $\frac{1}{4}$-acre plots was set up to test weaker solutions of the herbicides used in Experiment A with the same methods of application. These are reacting much more slowly and the killing effect was not taken. A complete report will be made on all plots in the second year after application.

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[1] Sixteen pounds of acid equivalent per 100 gallons of carrier.

[2] Twenty-three and one-half pounds of acid equivalent per 100 gallons of carrier.

DISCUSSION

All research in this report has been devoted to graded strip mined lands. In order to continue grading, it is necessary to know what conditions are being formed and to have some idea of the productivity of the land. Physical conditions and chemical reactions have been studied in order to determine the ability of this material to support plant growth. It has been shown that some crops are more adapted to newly graded area than others and that certain crops, particularly legumes and grasses, should be the first species seeded on a graded area. There is a strong indication, that after a few years growth of legumes and grass, high yielding cash crops can be grown, but a specie, such as corn, will not produce on newly graded areas.

However, one must remember that all spoil banks are not suitable for leveling. Much of the spoil areas will have to be utilized in other ways.

There are four general types of reclamation that have been and will continue to be used. Some areas are suitable only for wildlife and recreational areas. Others can be used for forestation. Still others can be used for grass and legume pasture. Finally there are areas that are suitable for leveling and for crop growth.

FUTURE PLANS

Much of the work now in progress will be continued. These will include a detailed physical study, fertility requirements, and specie adaptation.

In expanding these general phases of work, the physical study will include physical measurements of the soil to determine what changes

the soil is undergoing under the factors of time and vegetation. Fertility studies and specie adaptation, will be continued in order to determine what fertility is required, if any, when different crops are grown either alone or in a rotation.

OUTLINE

I. Soil investigations

  A. Soil tests

    1. pH
    2. Phosphorus
    3. Potassium
    4. Boron

  B. Mechanical analysis

    1. Graded spoil banks
    2. Strata of the highwall

  C. Permeability

    1. Percolation
    2. Volume weight
    3. Pore space

II. Characteristics of the stratum in the highwall

  A. Chemical analysis

  B. Mechanical analysis

  C. Vegetation

    1. Greenhouse experiment

III. Forage Crops

  A. Adaptation

    1. Alfalfa variety study

  B. Yield

  C. Ferilizer

IV. Grain crops

  A. Wheat

    1. Nurse crop
    2. Yield

  B. Soybeans

    1. Fertilizer

2. Disease

C. Corn

1. Fertilizer
2. Previous vegetation
3. Yield

V. Tree killing

A. Percent of kill

VI. Discussion

VII. Future plans

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EAT:mlm
3-7-53